

Charles H. Williams.

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INJURIES OF THE EYE

AND THEIR

MEDICO-LEGAL ASPECT.

BY

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TRANSLATED

WITH THE PERMISSION OF THE AUTHOR

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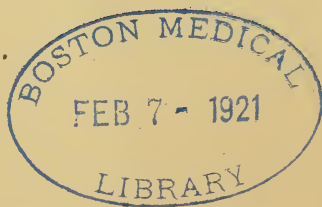
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PHILADELPHIA:
COLLINS, PRINTER,
705 Jayne Street

VIENNA, AUSTRIA,

June 10th, 1877.

DEAR DOCTOR:

I am pleased to hear that you propose translating my treatise on the "Injuries of the Eye," etc.

You have my full permission to do so, as well as my best wishes for your success in the undertaking.

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*	*	*	*	*	*

Yours, very truly,

F. ARLT.

TRANSLATOR'S PREFACE.

THE translation herewith offered to the profession is intended to fill the same gap in American medical literature which the original has so successfully filled in the German. Previous to the appearance of Professor Arlt's work, there were none but antiquated monographs on the subject; the references to ocular injuries in the best text-books were exceedingly brief and superficial, while medico-legal opinions in individual cases were too sparsely scattered through the archives and other periodical publications to call that attention to the subject which it demands, or to serve as a guide in case such attention had been aroused.

The nature of the subject is, from its complicated bearings, one in which both the therapeutic and forensic relations must be considered in conjunction, for frequently the forensic aspect of a case changes altogether when a therapeutic error can be proven to have been committed.

In this age of factories and railroads, w'en thousands of grievous bodily accidents occur annually, no

inconsiderable portion of their results falls under the professional care of the ophthalmic surgeon.

The carelessness of railway officials, the brutality of certain classes of the population, and even the censurable neglect by inexperienced and unqualified pretenders to the healing art, furnish a host of cases entailing more or less loss of vision, in which the criminality, or other culpability, of these parties becomes a question to be decided before our tribunals of law.

The extent and gravity of such injuries can be correctly estimated only by the expert; malingerers, hysterical or otherwise, are not infrequently claimants for pecuniary damages; and any practitioner not thoroughly conversant with modern ophthalmic diagnosis would certainly be baffled by the persistent statements and often strikingly consistent narratives of such individuals.

The expert's responsibility is by no means light. On the one hand, his decision may affect the reputation, liberty, or property of the accused party; on the other, the plaintiff, with the loss of the most important organ of sense, on which most likely he relied in carrying out his vocation, depends on his opinion for demanding either recompense or the punishment of the offender.

It remains for the translator to explain any casual deviation from the strict text of the original, which may

be found in this volume. He has deemed it preferable, in justice to those who would make use of the translation, and to whom a clear exposition of the leading facts is more desirable and of greater interest than a painfully accurate and verbal translation of German forms of expression, to avoid all such renditions. The correct interpretation of the author's sense is the chief desideratum in a translation, everything beyond this being of secondary importance.

The translator believes himself justified in taking such minor liberties with the phraseology as have been taken, in consideration of his intimate relations with his instructor and friend the Author, to whom, with his assistant, Dr. H. Sattler (now Professor in the University of Marburg), he would herewith express his hearty thanks for many favors shown.

In conclusion, he would express his obligations to his friend, Dr. E. C. Spitzka, of New York, for valuable assistance in the translation.

AUTHOR'S PREFACE.

IN my capacity as a member of the medico-legal commission of the University of Vienna,¹ I have frequently remarked that in cases where traumatic affections of the eyeball are concerned, physicians, even when called upon as experts, are extremely superficial in their opinions and decisions. Even in certain apparently accurate and elaborate medico-legal opinions, it can be easily seen that the author was not thoroughly conversant with the specialty in question. The chief cause of these imperfections is, at least in my opinion, that most professional men have no opportunity of studying these difficult cases; these latter are not even separately noticed, much less discussed in our text-books and clinical demonstrations, and the monographs on

¹ The criminal courts of Austria have officially appointed physicians ("Gerichts-ärzte") who, among other duties, give elaborate medico-legal opinions. These opinions ("Gutachten") are sometimes submitted to the "Medico-legal Commission" ("Begutachtungs-commission") of one of the Austrian universities for revision.—TRANS.

the subject¹ are almost exclusively in the hands of specialists, and either unknown or inaccessible to the general practitioner. I have, therefore, resolved to write a short and succinct account of these injuries with special reference to those facts, a knowledge of which is essential to the medico-legal expert.

The "Wiener Medicinische Wochenschrift" (1874) was first selected as a medium for this publication, as by this mode I hoped to call the attention of the medical public more generally to the necessity of a careful examination and a correct diagnosis of these affections. The favorable notices which it received from my colleagues in the specialty, and the rapidity with which the few reprints were taken, decided me to publish a new but unaltered edition in book form.

Specialists will find little that is new in these pages. Should any one, however, undertake a strictly technical and exhaustive monograph on the same subject, I am in hopes that my outlines may serve as a basis.

On the reader's part, I must necessarily presuppose an acquaintance with the modern means of investigation. By these I mean not only the determination of the condition of refraction and the

¹ I am only acquainted with two, that of W. Cooper and that of Zander and Geissler. They will be found more particularly referred to in the course of these pages.

examination of the acuteness of the field of vision, but also the use of the ophthalmoscope. Any description of the latter, however practical and thorough, would be perfectly useless unless accompanied by actual manipulation with the instrument itself. In case a physician, called upon to deliver his opinion as an expert, should not possess the above-mentioned requirements, I can only advise him to transfer the case into the hands of some colleague to whom they are more familiar. Without an accurate registration of the various appearances in the injured eye, the delivery of a correct medico-legal opinion becomes an impossibility. Medico-legal opinions, however, are by no means rare, even at the present day, in which even the existing degree of vision and its changes are passed over in silence. Should I be able to contribute in some degree to rendering the occurrence of such "*Opprobria artis et scientiæ medicæ*" impossible for the future, I shall consider the object of this little work accomplished.

I have found it convenient to divide all the injuries of the eye into three groups, viz.:—

I. Injuries produced by sudden compression or concussion of the eye.

II. Injuries produced by the entrance of a foreign body not acting chemically. In cases of this kind the foreign body may be either lodged in the eye or to either side or even behind it, or it may not remain at all. The coincident injury of the

lids, lachrymal apparatus, and the bony walls of the orbit, must be left to the province of general surgery.

III. Scalds and corrosions of the eyeball.

The *fourth* chapter will be devoted to the discussion of *such affections as are either feigned or produced artificially and intentionally.*

In each of the groups mentioned, a certain anatomical order will be followed, this being the most appropriate plan; and the discussion of each head will be further subdivided into its Diagnosis, Prognosis, and Therapeutics, for this method has appeared to me the only one by which the more complicated injuries can be referred to their proper place. I have considered chiefly the principles of therapeutics, because in the investigation of an injury to the eye the question is often brought up: may not the evil termination of such an injury be due, in whole or in part, to malpractice?

Before proceeding further, I would desire to make some general remarks (which I cannot consider superfluous).

In registering the *status præsens* it is well not only to examine the function of the injured eye, but that of the uninjured eye also, each, of course, separately. The injured organ may be the very one on whose integrity the patient relied to carry on his avocation, and in case sympathetic affection should threaten the other eye, it will be found of great advantage to have noted the degree of

vision of this eye at the time of the injury. The faculty of discriminating between light and darkness (quantitative perception of light) may be temporarily, as in the case of hemorrhage into the vitreous humor, or permanently annihilated. In case qualitative perception of light should still exist, its degree should be expressed numerically; for instance, the greatest distance at which the number of fingers, held up before the patient, can be counted in ordinary daylight, or at which letters and other objects of a definite size, as Jaeger's or Snellen's test-types, can be recognized. At the same time, it is important to see whether the vision is susceptible of improvement by the use of spherical or cylindrical, concave or convex glasses; and further, whether the necessity for such correction existed before the injury in consequence of changes in the form of the lens or of aphakia, or whether it was caused by the injury. Of equal importance is the examination of indirect vision, as to its depreciation or total loss. Where very fine distinctions are not an object, this may be accomplished by closing the one eye of the patient and inducing him to fix the eye under examination on some stationary object, placed at a distance of, say two feet, then the examiner passes his fingers (or, if the room be darkened, the flame of a candle) from various points of the periphery towards this fixed point, and notes at which points they can be counted. It is only where neither

peripheral nor central vision is diminished that the ophthalmoscopic investigation may be regarded as not essential.

In studying the relations between the condition of the eye and the cause of its damage, *we should never forget that not infrequently abnormalities are found which existed, without the patient's knowledge, previous to the injury*, and thus we may avoid falling into the error of ascribing something to the injury which has but a very slight if any connection with it.



INJURIES OF THE EYE.

CHAPTER I.

SUDDEN COMPRESSION OR CONCUSSION OF THE EYEBALL.

§ 1. WE include in this division those injuries which are caused by the action of a blunt instrument, and which result in a solution of the normal continuity and contiguity of certain elements, *without a penetration of these tissues by the offending agent.* The eyeball, in such cases, is either contused or indented in some small area; or, in case the surface of the instrument causing the injury was very broad, it becomes momentarily flattened throughout its whole extent. Very similar in every respect are cases where the eyeball has been thrown into violent oscillations by some cause acting directly or indirectly through the head, or even the whole body.

An eye, injured in this manner, exhibits, independently of the palpebral changes, the following appearances: extravasation of blood under the conjunctiva; opacity, with subsequent inflammations and suppuration of the cornea, either with

or without a solution of its surface continuity; rupture of the sclerotic coat, near the corneal circumference (rarely in its posterior portion); hemorrhage into the anterior chamber; more or less laceration of the iris; paralysis (or more rarely spastic contractions) of the sphincter; suspension of accommodation; bursting of the capsule; overstretching, or laceration, of the zonula, with various degrees of formative and other changes in the lens; choroidal rupture with hemorrhage into the vitreous humor, and disturbance of the retinal function from still other causes than those mentioned.¹

The recognition of many of the enumerated changes may, for a time at least, be rendered difficult or impossible by hemorrhage into the anterior chamber or the vitreous humor, and, later, by the products of reactionary inflammation, or consecutive cataractous changes in the crystalline lens. Under such circumstances, we will, in many cases, not be able to give a definite opinion as to the seat, degree and results of any established process until after months of patient observation.

Where our attention is not called to the eye by the history of the case, it will frequently be di-

¹ According to the investigations of Dr. Berlin (see § 18), extravasations of blood occur in the region of the ciliary body as a result of sudden compression of the bulb. These are, however, not demonstrable during life, and can only be recognized by post-mortem examination.

rected thereto by signs of contusion of the lids, of the orbital margin, or of the face in general. On the other hand, we may be tempted to neglect the organ of vision on finding wounds or scalds, as will be described in § 20 and § 31, and fail to seek for complicating symptoms of concussion or compression.

In order to understand the immediate effects of sudden compression, we must constantly bear in mind that the non-compressible fluid contents of the eyeball—the aqueous and vitreous humors—are surrounded by membranes which are only slightly elastic; and that the capsule of the eye, in its greater part, is surrounded by the extremely elastic and thick adipose cushion of the orbit, which renders any pressure of the eyeball against the bony walls of this cavity very difficult, unless an extremely large foreign body enters the latter. A partial compression of the eyeball, on a spot diametrically opposite the seat of the injury, is prevented by the equable distribution of the elastic cushion in which the eye rests; consequently, when searching for the cause of changes in such a locality, we must seek for some other explanation than Dr. Berlin,¹ with others, seems inclined to accept.

When a foreign body impinges against the eye

¹ Zur sogenannten *Commotio Retinæ*, Zehender's *Klin. Monatsbl.* 1873, p. 42.

with a certain degree of sudden force, and, on account of certain physical properties, such as size, bluntness, etc., cannot perforate its tunics, it expends this force by contusing the surface against which it strikes, or it causes either flattenings or indentations, the degree and extent of which depend on the character of the injuring surface, while, in the moment of the injury, perhaps, no movement of the eyeball, as a whole, takes place. Now an indentation or a flattening of the eyeball cannot plausibly be considered possible, unless the same also changes its form *in toto*. Suppose we consider the point attacked as the pole, and the direction of the attacking force as the axis of a sphere, then the equator of the latter must become longer at the moment of the injury. Any resistance at the opposite wall, especially if distributed over an extensive area, will only serve to increase this change of form. The occurrence of a gap in such a wall, or of a projection upon it, will, when the globe is pressed against, produce a localized bulging—in the former case corresponding in shape and dimensions to the gap, and in the latter to an indentation or perforation of the sclerotic; but such conditions hardly, if ever, occur. An impinging force is not transmitted through the contents of the bulb to a point diametrically opposite, because the aqueous, as well as the vitreous, humor transmits pressure to *every* part of the sur-

rounding capsule. In accordance with this, symptoms of compression or rupture of the retina never take place at a point directly opposite that where the injury was applied. The changes which are found on the opposite part of the choroid cannot be explained as analogous to cranial fissures, or to intracranial hemorrhage in certain cases of cranial injury—or *quasi*, as the result of contre-coup, according to Knapp ("Arch. of Ophthalmology and Otology," Vol. I. No. 1, p. 171); for the simple reason that neither in the hardness nor the absolute inextensibility of the cranial wall does the sclerotic resemble the latter; and for the additional and still more conclusive reason that a sclerotic rupture has never been found at the same place as the choroidal rupture or hemorrhage; as, also, that sclerotic rupture is of rare or non-occurrence in those very localities where choroidal rents are most frequent.

If the eyeball is flattened at its anterior pole (the most frequent case), it must for the nonce become longer in its equator. This dilatation will be at its maximum in the equatorial zone, but at the same time it will be also considerable at both sides of it. The choroid is entirely fixed to the corneo-scleral ring by the ciliary muscle, and posteriorly it is closely united to the sclerotic around the entrance of the optic nerve, but in the intermediate region the union between the two tunics is less intimate; in fact, we are justi-

fied in believing that the choroid can glide, as it were, upon the sclerotic. About the middle, between the two points of closer union, the two membranes are again closely united by the *vasa vorticosa* and some dense connective tissue. The areas of closer union, at the ciliary region and the entrance of the optic nerve, are increased by the passage of arterial and venous rami. Now, if by flattening of the globe, its equator is elongated, while the intraocular pressure remains fixed, the tension produced in the course of such an elongation is concentrated on a comparatively limited area, its extensibility becomes exhausted, its vessels give way, and finally the membrane itself ruptures. Such ruptures are naturally in a direction transverse to that of the extending force, and consequently run parallel to the periphery of the optic papilla, in other words, are concentric to the posterior pole of the eyeball.¹ A ramifying rupture may result, or smaller rents may take place on either side, all in this same concentric direction; and we must not allow the deviation of a lesser rent hither or thither to rank as anything but an exception which proves the rule.

Very probably vascular rupture occurs in a per-

¹ Among others, Saemisch ("Klinische Monatsblätter," 1866, p. 112) and Von Stellwag ("Lehrbuch," 4. Auflage, p. 322) have given tension as the cause for choroidal rupture.

fectly analogous manner in the vicinity of the anterior attachment of the choroid, but there its actual demonstration is impracticable until after death. (See Dr. Berlin's experiments in § 18.) Ruptures of the choroid, in front of the equator, have been thus far observed only in those cases in which the eyeball has been injured in this region by a blunt-edged instrument. In a case of this kind the choroidal rent can be explained on the strength of the indentation of the sclerotic only. In such cases ruptures also occur posterior to the equator and in the same meridian, and can be easily explained by a pulling forwards of the choroid.

Without question, the greatest difficulties are presented in endeavoring to account for certain lacerated wounds which are found on the anterior zone of the sclerotic, which implicate the *tunica uvea*, and which result from blunt force. It is remarkable that lacerations of this nature, through which more or less of the fluid contents of the eyeball, and sometimes even portions of the iris or the whole lens, escape instantaneously, always run parallel or nearly so to the corneal margin; and also that they occur almost invariably at the upper part, usually above and to the inside. We should not forget, however, that exceptions may occur such as, for example, ruptures below and to the inside.

The explanation¹ offered for this fact, that the eyeball on being struck from below or from below and outwards, is pressed up- and inwards against the orbital margin, and that meeting an insurmountable obstacle here, a rupture of the sclerotic and an expulsion of the lens takes place at this locality, has been already objected to by Manz, who says: "It must be borne in mind that it is not necessarily the two portions of the eyeball directly compressed (namely, the one pressed by the instrument, the other by the orbital wall), which give way, but that the rupture may occur at a relatively free region, which, while it is subjected to the maximum of tension, offers a minimum of resistance; and this region is that part of the sclerotic which adjoins the upper and inner quadrant of the cornea."² If it be granted that larger foreign bodies do not frequently come from any other direction than from below, and below outwards, and that the eye, in the moment of threatened danger, darts upwards and inwards, then the point where direct violence is applied will usually fall midway between the equator and the outer and lower part of the corneal margin. In this case the locality of the rupture will be exactly in that circle, which, with reference to a

¹ Zander and Geissler, "The Injuries of the Eye," Heidelberg and Leipzig, 1864, p. 373.

² "Klinische Monatsblätter," 1865, p. 177.

diameter drawn from the point of injury to the point of counter-pressure, may be called its equator. It is not to be wondered at, then, that the sclerotic will suffer the greatest tension in this circle, and that it will give way at that point which at the moment of the injury has the least support from without. Should this injury, however, as in a case observed by Schröter at Ruete's clinic ("Klin. Monatsblätter," 1866, p. 245), strike the upper and external part of the anterior sclerotic zone, the rupture will, following the law above promulgated, take place below and inwards. In any case this holds good, that when the anterior sclerotic zone is struck below the uveo-scleral, rupture takes place above, and that such rupture occurring towards the *nasal side* is adducible to violence coming from *without*, while if the rupture occurs below, sudden compression of the *supra-corneal* part of the sclerotic tunic must be presupposed.¹ The constant parallelism of the

¹ A hostler received from a horse a kick, which implicated the right temporal region and the upper and external part of the right eye. Two weeks later several cicatrices were found on the temporal region. The orbital walls were intact, the eyeball flaccid and diminished in size, and the conjunctiva slightly injected. A recent slightly retracted cicatrix, with included pigmented tissue derived from the iris and the choroid, was parallel to, and about one line distant from, the inner and lower circumference of the cornea. The cornea itself was round, somewhat flattened, its circumference diminished, and its

sclerotic rent to the corneal margin has an *additional reason* in the histological fact, that the fibres of the sclerotic coat run parallel to the latter within the confines of the ciliary region. The ruptures of the iris, and more particularly the iridodialyses, are easily accounted for by the dilatation of the cornea-scleral ring, resulting from the flattening of the cornea; with the former the ciliary muscle is intimately connected, the iris less so. Rents which run through the iris in the radiating direction might render justifiable the supposition of contraction of the pupil, and pressure of the lens on the tense membrane.

The tension or laceration of the zonula, and the rupture of the anterior or posterior capsule, as well as the resulting changes in shape and position of the crystalline lens, are likewise attributable to the momentary dilatation of the cornea-scleral border; in reality it sometimes occurs without the latter, for instance, when the eye has been subjected to a species of concussion. Such cases to be explained by the probable fact that the relatively heavier lens is thrown into more excessive motions than the lighter humors which surround

posterior surface covered with a delicate fibrinous layer. Lens and iris were wanting, the sole remnant of the latter being a small semi-lunar rim with a lacerated, serrated border. Doubtless the iris had been dragged with the lens, when the latter had been forced through its capsule, and expelled from the eye by the force of the blow. (Schröter, *l. c.*)

it. We are yet unable to furnish a satisfactory reason for the paralysis of the sphincter iridis and the ciliary muscle, but the obscurity upon this point may yet be gradually dispelled by following the method indicated by Dr. Berlin (§ 18).

In the majority of cases belonging under this head, the changes observed bear no proportion to the degree of violence suffered by the eye. The nature and gravity of the injury is rather modified by, and dependent upon, the *peculiar constitution of the eye* and the act of violence together, the latter usually being the less important item. Not only old age, with the fragility of tissues accompanying it, but also certain anomalies of refraction, as the higher degrees of short-sightedness, and pre-existing, frequently not previously noticed, ectopia of the lens, will form grave elements in the determination of ophthalmic injuries due to criminal acts. The position of the eyeball, as regards its depth in the orbit, is another element deserving of consideration.

§ 2. A frequent result of the impinging of blunt bodies against the eye, as also of the lids and the orbital margin, is *extravasation of blood beneath the conjunctiva*, into the loose subconjunctival connective tissue. This hemorrhage can, by continued exacerbations provoked through coughing, straining, or sneezing, reach an enormous extent, causing the dark red, suffused, and more or less

tense conjunctiva, to overlap the cornea in part or *in toto*. Subconjunctival hemorrhage, occurring several days after injury, leads to the suspicion that an internal hemorrhage had taken place at the time of the injury. (Berlin, *l. c.* p. 68.)

Diagnosis, Prognosis, Treatment.—In itself, the condition last mentioned, which is simply a temporary disfigurement, which causes at most some inconvenience by the resulting pressure and tension, is of no serious moment. Its presence, however, should always demand careful ophthalmoscopic investigation, as serious changes may result at the same time, internally, or behind the eye.

The blood itself is absorbed in a few days, although a yellowish tinge of the white of the eye may remain for a long time. The latter color, in case of internal hemorrhage, may make its appearance within a few days. The differential diagnosis between this condition and chemosis of the conjunctiva, which appears as a symptom of inflammation, is easily made by the absence, in the former case, of all inflammatory symptoms; symptoms which, in the latter case, would have to be very severe to produce such a degree of swelling and reddening as to render it liable to be confounded with the former.

In a few instances *subconjunctival cysts* have been recognized as a result of contusion of the locality at which they occurred. I have seen several such cysts.

Cold applications, alone or combined with alcohol, or even tincture of arnica, as well as the avoidance of everything which might interfere with the returning venous circulation, are recommended. Incisions will rarely become necessary.

§ 3. *Contusion of the Cornea* by a relatively small body, with or without very inconsiderable interruption of the surface continuity, frequently causes *keratitis with suppuration*, which usually terminates in *abscess*, rarely in ulceration, and then becomes one of the most dangerous affections of the eye. The cause of such injury is rarely due to a second person; it is usually due to some unfortunate accident, to carelessness of the injured party himself, or to impingement of a piece of metal, stone, wood, or the like, or to striking against a wisp of straw or corn husk. Whether the result mentioned can occur, if the contusing agent strikes the lids and not the cornea directly, has not been satisfactorily proven.

Such *keratitis* takes place more frequently in aged than in young persons, which would justify us in attributing a certain predisposition to old age as its peculiarity. Besides this, we frequently find conjunctival blennorrhœa, and especially blennorrhœa of the lachrymal sac, accompanying these corneal abscesses, and are forced to attribute the malignancy of this complication, in part at least, to the accompanying blennorrhœa. Consequently,

the advice is very good to do away with the lachrymal stenosis by slitting the canaliculus and introducing the sound ; and further, that whenever an operation implicating the cornea is to be performed, this prejudicial complication, where it exists, should be previously removed. The evil influence of lachrymal obstruction, on the results of cataract operations, has been amply demonstrated by statistics.

Diagnosis.—The portion of the cornea struck is marked by a corresponding zonal ciliary injection and a light-grayish disk-shaped opacity, which assumes a more decided yellow color the greater the number of purulent layers that lie behind each other in the cornea. Should we see the abscess only after a part of the pus has been discharged, the margins will appear somewhat thickened and markedly opaque, while the centre will be irregularly gray and more or less depressed. We may then be in doubt whether we have an ulcer or an abscess before us ; but practically, this question is of little value, for, in the one case as well as in the other, extension often takes place, when all other inflammatory symptoms, such as ciliary injection, pain, photophobia, and increased flow of tears have become ameliorated or have subsided, and it usually proceeds with equal rapidity in all directions. An ominous prodrome of this extension is a light-gray halo which joins and surrounds the infiltrated and tumefied margin of the ulcer.

With pus in the cornea we find, almost without exception, *pus in the anterior chamber* in varying quantities, sometimes hardly visible above the limbus, at other times filling one-half or two-thirds of the anterior chamber. Should iridocyclitis make its appearance in addition, even a moderate accumulation of pus may cause the most excruciating pains, continuing whole days and nights, and for which no more decided a remedy exists than paracentesis of the cornea. Prof. Horner has given some hints worthy of note on "Pus accumulations of the anterior chamber." (Dissertation of M. Bukowa on "Hypopium-keratitis." Zürich, 1871. Zehender, "Klinische Monatsblätter," 1871, p. 182.)

Prognosis.—All abscesses are followed by at least an incurable opacity of the cornea, of greater or lesser density, which, by reflection, or by diffusion of the rays of light, causes a defect of vision; especially as these abscesses either occupy the centre of the cornea, or at least extend to it. In many cases, even with the best treatment, and the greatest care on the part of both physician and patient; the cornea may become destroyed to such an extent, that not even the operation of iridectomy will improve the case. The further results of extensive or total suppuration of the cornea, such as the formation of staphyloma, and the occurrence of phthisis bulbi, need not be discussed here.

Treatment.—The first indication to be fulfilled is effected by the application of cold, immediately after the injury. As soon as suppuration sets in, however, cold applications become useless, and, as a rule, should be soon replaced by lukewarm fomentations. (These should be composed of small, thin compresses, saturated in infusion of chamomile.) As a general thing it is most advisable to drop atropine within the lids, to protect both eyes against excessive light, to keep the injured one under a charpie-bandage, with more or less compression, and not to allow the patient to walk about in the open air. In many cases we may expect, that under the employment of moist heat and the charpie-bandage, the former applied for ten or twenty minutes, several times a day, the suppurative process will have ceased in the mean time. If the previously mentioned symptoms should indicate progression, or should the latter have become evident, after an observation extending over a day or two, the pus in the anterior chamber reaching the pupillary margin or beyond it, and the patient suffering extreme pain, operative interference should not be delayed. Either of the latter symptoms, much more their combination, is in itself an indication for the prompt performance of the operation, of which we will speak. The method which has thus far yielded the best results is that of Saemisch of Bonn. ("*Ulcus corneæ serpens*," 1869.) As the operation is fre-

quently followed by severe though not protracted pains, and sometimes by syncope, the patient is afterwards brought to bed. The method of operating, usually performed without anæsthesia, is as follows: The eyeball being well fixed, the knife of Graefe, with its edge directed forwards, is passed through the still normal corneal tissue at one margin of the purulent accumulation; it is then pushed closely behind it through the anterior chamber, and made to emerge near the opposite margin, in such a manner that the counter-puncture shall fall in normal corneal tissue again. Then, without fixing the eyeball, the section is completed by drawing the knife slowly from behind forwards, the back of the knife remaining directed, while this is being done, to the centre of the curvature of the corneal surface. If, for example, the abscess occupies the central region of the cornea, the points of puncture and counter-puncture can be so chosen that the section will run in the horizontal meridian, dividing, consequently, the cornea into an upper and a lower half. It would, however, be equally admissible in such a case to select a lower or a higher line for the passage of the knife through the infiltrated area. If we choose a lower line, we must direct the edge of the knife somewhat downwards; if a higher, it should be directed a little upwards. Our object is to pass through the cornea in a vertical direction, so that the section shall not be a curved but a linear one; that is,

one following the greatest circle of the cornea, for it is such a section alone which will afford the necessary gaping of the margins of the cut to secure the curative object. A lance-shaped knife, which would have to be depressed after puncturing, to avoid catching in the iris or lens capsule, would not enable us to make a sufficiently long cut.

The aqueous humor should drain off slowly. The pus in the chamber is not directly removed, but left to resorption. Sometimes, after the draining away of the aqueous humor, masses of pus protrude from the wound, and can easily be seized with forceps, and pulled out altogether, as the pus cells are held together by tough, fibrous connecting substance. The patient operated on should be kept on his back for from one to two hours; then atropine is to be instilled, and the protective bandage applied. Should dilatation of the pupil not soon occur, atropine should be reapplied every two or three hours. The edges of the wound must be separated at intervals of twelve or twenty-four hours (employing for the purpose, instead of the ordinary knife, a thin probe, or Weber's lachrymal knife), until decided diminution of the pyoid infiltration, and resolution of the nidus of accumulation, especially at its margins, and disappearance of the dull halo, elsewhere considered, take place and continue. The permanent existence or the reappearance of fibrinous exudation masses, behind the nidus, are indications for a repetition of

the procedure last mentioned, or even a renewal of the original operation, at the same or at another place. It may happen that the section alone produces a permanent and progressive improvement, but it is also possible that this result is only achieved after a reöpening of the cut, even as often as ten times. Among a large number of cases treated in this way, notwithstanding the most implicit obedience of the patient and the greatest care on the part of the physician, we have sad occasion, now and then, to regret the loss of an eye, or even of its fellow. It seems that the changes produced by iridocyclitis, which are recognized by a broad, dark red zone around the cornea, and considerable sensibility on palpation, lead to phthisis of the globe, and thus account for the lack of success in this plan of treatment.

§ 4. *Rupture of the Eyeball.*—It is doubtful if *rupture of the cornea* can occur as the result of sudden compression. In the few cases where this is said to have been noticed, the suspicion is not excluded that the cornea has been directly struck by a more or less sharp edge or corner of the injuring agent.

Ruptures of the cornea-scleral margin are, strictly speaking, to be considered among the sclerotic ruptures.

Cases of *rupture of the sclerotic* are not rare. Such rents extend, without exception, to the

ciliary body, even through it. Of *ruptures in the posterior sclerotic area*, only one case is recorded (by Bowman), and here the rupture was not recognized until after the eyeball had been enucleated. (White Cooper, "On Wounds and Injuries of the Eye." London, 1859, p. 197.)

Diagnosis.—The *sclerotic rent* is linear, or slightly arched, more or less serrated, from 6–12 millimetres long, and usually runs parallel to the limbus corneæ, at a distance of from 2–5 millimetres from the latter. In one case only (Schröter, "Klinische Monatsblätter," 1866, p. 248) did the rent run at an acute angle.¹ If the rupture is

¹ A tinker, aged 34, fell with his whole weight upon an anvil, so that the one corner of the anvil struck the lower part of the left eyeball, in the neighborhood of the internal canthus. Among other appearances there was found on the day of the injury a rent in the sclera and the overlying conjunctiva, which extended from the external corneal margin, outwards, several lines in the horizontal meridian. After four days the conjunctiva was less chemotic, and a second longer rent could be seen which was covered by conjunctiva in part, and which began at the outer end of the first rent, and thence passed upwards and inwards parallel to the corneal margin, in such a manner as to form a sharp-angled flap of sclerotic substance, which, together with the cornea, was displaced downwards and inwards. Five days later the further reduction of the conjunctival swelling permitted the recognition of a third subconjunctival rent, which passed from the inner and upper corneal circumference, in a flat curve, with the convexity looking downwards, several lines to the inner side. During the retrogression of the inflammatory process the eyeball contracted in size, espe-

near the cornea, the *conjunctiva* is also implicated in the rent, in which case the lens may have escaped in whole or in part; or only a part of the iris, the capsule, the lens, or the vitreous body may protrude from the wound.

If the conjunctiva remains intact, it forms a sac, the contents of which may consist of blood, aqueous humor, iris, lens, or vitreous humor, and the sclerotic rent may be more or less obscured by these contents. The flaccidity of the eyeball, which may continue even after union of the wound, the detraction of a part of the iris towards the region where the suspected rupture is supposed to lie (apparent or real coloboma of the iris), and perhaps even the demonstrability of changes in the lens, provided always that the anterior chamber is not filled with blood, all point, in these instances, to the diagnosis, if we have been unable to arrive at a conclusion, by accurate inspection of the conjunctival projection, or if chemosis should intervene. The presence of the lens beneath the conjunctiva is made manifest, besides shape and form, by a complete reflection of light (shining appearance) at the capsular margin, and by the appearance of opacity, by the various tints of cataract, when the blood has been absorbed. In

cially in the cornea, which was slackened by the numerous scleral rents. The lens had, probably, escaped at the moment of the injury.

course of time the lens may become absorbed, except a remnant of fat and calcareous salts, but probably only when the capsule has been opened.

This rupture always presupposes the employment of some instrument, wielded with great rapidity and force. The cases thus far noticed do not justify us in assuming the pre-existence of a certain disposition, even though such ruptures have been almost exclusively found in adults, and in them, relatively, most frequently in the second half of life.

Prognosis.—It seems, judging from all observations thus far made, that the force of the blow exhausts itself in the laceration of the ciliary body and the sclera. The retina and choroid (behind the ora serrata) are changed very little, or else not at all. The circumstance that such ruptures take place principally upwards, or inwards and upwards, rarely outwards and upwards, and most rarely below, points to the fact that the eyeball has been struck in its anterior circumference not far from the cornea. The etiology of such ruptures has been already hinted at in § 1.

The reaction on the injury, as its direct result, does not usually reach a high degree, probably on account of the prolonged diminished tension of the tunics.

The danger lies principally in the extensive escape of vitreous humor, which induces subchoroidal hemorrhage, and later irritation of the iris,

either by impaction in solidifying cicatrices, or through pressure on the iris or ciliary body by the lens, provided that it remains either wholly or in part within the eyeball. Compare § 14. In one case (Dr. Schrag, "Inaugural Dissertation on Sclerotic and Choroidal Rupture." Leipzig, 1870) where, after the impinging of a piece of wood, a sclerotic rupture with prolapsus iridis and hæmophthalmus anterior, was accompanied by complete loss of light-perception, *sympathetic disease* of the other eye appeared four weeks later. (Zehender's "Klinische Monatsbl.," 1871, p. 157.) The same result followed a push by a passer-by, in the case of a woman aged sixty-nine. In this case, probably on account of the pressure produced by the luxated lens on the ciliary body. (Schröter, "Klin. Monatsbl.," 1866, p. 249.)

If considerable vitreous humor has entered the wound we have reason to fear either too severe reaction, following the extreme collapse of the globe, or immediate copious choroidal hemorrhage; or, again, gradual solution of the retina, manifesting itself after weeks and even months.

The filling of the anterior chamber with blood is a matter of less serious import. *There are numerous cases extant, where individuals have, after the escape of the entire lens from the globe, been able to see about as well as patients operated for cataract, by means of cataract spectacles, and have remained in this condition for years.*

Treatment.—Our first object is to prevent any further escape of the contents of the eye-globe. To insure this, it is not only necessary to keep the patient quietly on his back, at the same time employing cold applications, but also to check palpebral motion (by closing both eyes), and to avoid everything which has a tendency to interfere with the return of venous blood, through the descending veins, such as coughing, straining at stool, etc. If any considerable portions of vitreous humor or of the iris should hang from the wound they may in quiet patients be cut away, but this is not essential. The protruding vitreous mass becomes opaque after a few days, constricted at its base, and is finally thrown off; the iris becomes fixed in the cleft, then gradually bridged over and flattened off by exudations and the conjunctiva; where the latter does not occur, it should be pared down. If the lens press on the iris or the ciliary body we should endeavor to extract it.

In cases where the conjunctiva is not lacerated, but simply bulged forwards in a sack-shape, it is better to delay the opening, and removal of the contents of the sac, until we are justified in believing (judging by the tension of the globe) that the rent of the sclerotic and tunica uvea has already closed.

Should panophthalmitis develop, marked by protrusion of the pus-distended eyeball, its termination in phthisis bulbi can hardly be averted.

The compress bandage is the agent from which we may expect the most good, and the violent pains can be lessened and shortened only, first by ice cold, later by lukewarm applications, accompanied by the employment of opiates and hydrate of chloral; finally, when the escape of pus is delayed at any pointing portion of the sclera, an incision at the most prominent part of such a pointing area is the only prompt remedy to free the patient from his tortures.

The most unfavorable cases are those in which on account of incarceration or irritating pressure of the iris (and ciliary body) by a luxated or swollen lens, or where, by later occurring hemorrhages into the vitreous space, a protracted inflammation of the uveal region is incited and kept up (with increase of intraocular pressure), there is danger of the occurrence of sympathetic iridocyclitis in the other eye. Compare article on "Sympathetic Ophthalmia" ("Wiener Med. Wochenschrift," 1873).

§ 5. *Rupture of the Inner Tunics* (iris, zonula, capsule, choroid, retina).

Ruptures in the Uveal Tunic (iris, choroid). These are generally noticeable, by extravasation of blood into the anterior chamber or the vitreous humor (hæmophthalmus).

Extravasation of blood into the anterior chamber

in an eye previously free from inflammation (excepting cases of scurvy and of certain neoplasms in the eye), always point to concussion of the eye, or to some penetrating wound. It is usually derived from the iris, rarely from the ciliary processes or from the posterior half of the eye.

Blood may fill the whole chamber, or it may be present only in such a small quantity (in the groove between the iris and the sclero-corneal juncture) that it can be detected only by the most careful examination, perhaps by focal illumination alone. It usually is found below, but it may be situated above, or laterally, or between the fibres of the iris itself at the point where the rupture took place. In this case focal illumination may be our only means of detecting its presence.

In eyes previously healthy, especially in the case of young individuals, blood filling the whole chamber may be absorbed within thirty-six hours; but some of the coloring matter of the blood usually remains behind, and changes the color of the iris, especially where the latter is light-colored, in the manner of a yellow or pale red lining, through which the fibrous appearance of the iris, unless the latter be inflamed, is clearly visible.

§ 6. *Hemorrhage into the Vitreous Humor*, after concussion of the eyeball with choroidal rupture (or after penetrating wounds beyond the lens.

system), causes disturbances of vision, varying in degrees up to simple distinction between full light and complete darkness, according to the locality and the amount of the extravasation. Blood present in considerable mass in the vitreous humor is itself sufficient to cut off all the light by absorption, and consequently can reduce the quantitative perception of light to zero.

If on account of coincident hemorrhage into the anterior chamber or of opacity of the lens, or of the cornea, an examination of the deepest parts of the eye by means of the ophthalmoscope be impossible, we may employ the same procedure instituted by Graefe in the case of cataract, to prove the functional integrity of the retina, in order to discover whether we have to deal with only an extensive extravasation in the vitreous humor, or the same complicated by *solutio retinæ* (by blood or serum between the retina and choroid) with laceration or commotion of the membrane. Should the patient, tested by the lamp in a dark room, have perception of light throughout the whole field of vision, an extensive hemorrhage into the vitreous humor may, indeed, be present, but by no means detachment of the retina. Should the quantitative perception be moderately diminished, and the perception of light more plain in the lower region of the visual field than in the upper, we are not yet justified in deducing a detachment

of the retina. A very copious hemorrhage, with a settling down of the coagula to the lower part of the vitreous space, will serve to explain the decrease, as well as the irregularity, of perception. If the nature of the case is such as to demand the earliest possible prognosis, that is, to decide whether a retinal solution exist or not, direct the patient to move his eye suddenly and repeatedly upwards, in order to cause the coagula of blood to whirl around; then observe whether the *irregularity* of the perceptions is at all changed. We can also let the patient maintain a lateral posture for some time, and then observe whether the region of obscured perception shifts to correspond. Should it appear finally that there was an enormous difference between the perception of light above and below, and should it be also considerably decreased, detachments of the retina may be diagnosed. We cannot expect, as also in solution of the retina complicating mature cataract, to find the perception of light abruptly ceasing at a certain line of the visual field, because the diffusion of light by means of the extravasated blood changes the refractive relations. Incorrect projection of the flame can help to determine this point. At the same time we should not lose sight of the fact that a detachment of the retina may appear later, or increase when the opacity of the vitreous humor shrinks. Finally, I will

not deny that very slight solution of the retina, coexisting with hæmophthalmus, may be overlooked altogether on account of the diffusion of light, in spite of the most careful testing of the luminous appreciation, and that in many cases we may be uncertain when the symptoms detailed above are coincident with very extensive hemorrhage into the vitreous; yet in the examination of the perception of light by homocentric light, a great advance has been made as contrasted with the earlier method of testing. (Graefe, "Archives of Ophthalmology," III. b, 367.)

Prognosis of Hæmophthalmus Posterior.—Small quantities of blood in the vitreous humor, in themselves, cause only a more or less remarkable depreciation of the acuteness of vision. The injured patient complains of a dark cloud or flake floating before his eye; in the first few days, sometimes, white objects appear to be red.

Absorption here is much slower than in the aqueous humor, even should no further recurrence take place; from five to six weeks may elapse before it is completed. Very frequently floating scotomata remain behind for a long time, or become permanent; whether a fixed scotoma or a more or less extensive narrowing of the visual field remain, depends partly on the seat and size of the choroidal rupture, partly on the proximate and distant changes in the retina. Compare §§ 8 and 9.

So long as the blood, accumulated in the chamber, or in the vitreous space, should prevent an insight into the deeper parts of the eye, we should be reserved in our diagnosis, especially if the eye had not been perfectly healthy (for instance, if it had been highly myopic), or the injuring force had been very great; inasmuch as the quantitative perception of light is suspended for two or three weeks by excessive accumulation of blood in the vitreous humor, after which time perception of luminosity could return.

I should here remark, that after extensive hemorrhages of traumatic origin, not only the aqueous humor, but also the episcleral connective tissue, exhibit for many subsequent weeks a yellow tinge.

§ 7. *Laceration of the Iris*, following contusion of the globe, occurs most frequently at the ciliary margin, presenting every degree, from the very least, scarcely discoverable, to complete separation from the ciliary body; rarely does the iris give way in the direction of its radii, and much rarely still do we find small fissure-like rents at the pupillary margin only, or narrow slits between the radiating fibres, as the source of the blood in the anterior chamber.

After partial separation of the iris at its ciliary margin (iridodialysis), the sphincter pupillæ finds

no resistance at that point by the radiating fibres, and passes from the condition of a circular arc to its chord, by which change the pupil receives a kidney-shaped form. This deformity is at the time of the examination frequently the only symptom which marks the existence of a slight dialysis. However, should the resulting gaps not be too small, we occasionally, when employing the ophthalmoscope, receive red light through them from the fundus oculi, provided the media are transparent. More extensive dialyses are characterized by the presence of a peripheral gap, a second pupil. In large gaps of this kind, the loosened part of the iris may occupy such a position as to reduce the natural pupil to a small slit, or to occlude it altogether.

Total, or nearly total dialysis, is followed by the shrinking of the iris to an ashy-gray membrane.

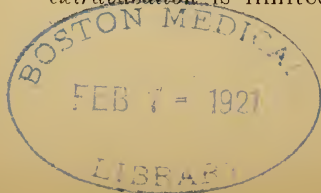
Radiating rents produce a complete or true coloboma; one or the other end of the coincidentally detached iris may be drawn towards the sclerotic rent (provided such a one accompanied the injury), or it may become applied to the capsule in the region of the natural pupil, and by inflammatory adhesion be fixed there. I saw one case in which, after a blow had struck the eyeball in the region of the insertion of the inferior rectus muscle, the iris was detached from the

ciliary body in its upper third, and at the same time torn through vertically from the detached ciliary to the pupillar margin.

Prognosis.—By itself, the laceration of the iris affects the power of vision only in those cases in which the natural pupil is exceedingly dilated, thereby producing dazzling, or if a second pupil has been produced, in such a position, and of such a size, through inaccurate accommodation, monocular diplopia. Besides this, more or less noticeable cosmetic changes are produced thereby. Serious iritis is not caused by it.

Treatment.—This injury has no particular therapeutic indications; rest, shading of the eyes, and cold applications in the beginning are all that is necessary. The absorption of the blood can probably not be hastened, although the suggestion to employ compresses, with tinctura arnicæ flor., deserves trial. On the other hand, it is altogether superfluous to open the chamber in simple hæmophthalmus anterior, in order to void the blood. Only when symptoms of hæmophthalmus posterior coexist (imperfect perception of light, increased tension), and resorption becomes delayed, are we called upon to procure a careful and gradual evacuation of blood from the chamber.

§ 8. *Ruptures of the Choroid.*—Frequently these ruptures only implicate a vessel or two, and the *extravasation* is limited to the parenchyma of the



choroid, or it passes *between* the *sclerotic* and *choroid* (in large quantities, only, when the eyeball has been at the same time opened), or it lifts off the overlying portion of the retina and may perforate the latter and enter the vitreous humor. As a higher degree of such rupture, a choroidal rent of greater or less length manifests itself in one or more places.

Diagnosis and Prognosis.—*Hemorrhagic extravasations in the choroid*, varying in number and extent, have been recognized after contusions of the eyeball itself, with other changes; these maculous or dot-shaped spots produce no visual disturbance by themselves. They soon disappear also, as a rule, without leaving any striking traces, although reactive inflammation may set in, and implicate the retina. Of course, their presence can only be recognized by ophthalmoscopic examination, and appears as blood-red maculæ or dots, in front of which the retinal vessels are seen to pass without interruption or deviation. In many cases, and this occurs, according to Berlin (see § 18), even in small extravasations, the corresponding part of the retina becomes temporarily dulled in the course of a few days, but it gradually clears up again.

Of a much more serious import are those vascular ruptures which lead to a displacement or even to a laceration of the overlying retinal portion. Should such change take place in the neighborhood of the

macula lutea, the patient will at once notice a diminution of his visual power; if situated more peripherically they, together with coexisting hemorrhage into the vitreous body, may, possibly, only be discovered by the ophthalmoscope, after being suspected on examination of the field of vision. During the first few days their presence may be difficult or even impossible to detect by the presence of blood in the vitreous body, or in the anterior chamber. Later, the detachment or perforation of the retina may be clearly demonstrable; or, on the other hand, be masked by consecutive opacity of the vitreous body.

Such lacerated wounds of the retina may unite, in such a manner, that the cicatrix may be hardly recognizable, and no serious functional impairment remain. Even detached parts of the retina may regain their functional energy after absorption of the blood. If inflammation should have followed, the partially restored function may again become disturbed by resulting retraction of the cicatrix. Such cases will have to be, as regards the ultimate result, retained for many months under the observer's eye.

§ 9. *Choroidal Ruptures* have been chiefly recorded as occurring in the region of the posterior pole of the eye, that is to say, on the temporal side of the optic disk; under peculiar circumstances,

however, also on the nasal side. Their etiology has been considered on pages 23-24.

Diagnosis.—At first the rent is marked by blood, which is partially situated in the rent, and partly extravasated, through the retinal rupture, into the vitreous humor; yes, it has been known to extend even into the anterior chamber. After the clearing up of the media, the sharply defined and jagged choroidal rent is seen, as at first a yellow, later as a white reflection of the denuded sclerotic. The margins appear red for a long time, later they are often strongly pigmented. Over this rent the retinal vessels run unchanged, unless a retinal vessel has been ruptured at the same time. Besides this, the signs of reactive inflammation in the immediate vicinity, perhaps also of partial folding and detachment of the retina, may be present. Further on, connective tissue fasciculi pass across the vitreous space immediately in front of the middle of the rent or in its immediate neighborhood, and prevent the rent from being seen in its whole extent.

We must expect choiroidal ruptures in or near the equatorial region if the eyeball has been struck or indented in this region by a blunt-angled instrument. Thus far, posterior choiroidal rents on the nasal side of the optic disk have been found only where a foreign body had impinged against the nasal aspect of the sclerotic. A posterior

choiroidal rupture on the temporal side of the disk does not exclude the possibility of an anterior choiroidal rupture on the same side, provided the globe has been indented on its temporal side in the equatorial zone.

In one case, an angular rent of the choroid, internal to the optic papilla, and in the equatorial region, was the result of the impinging of a piece of iron against the inner circumference of the right eyeball. Of the two sides of the angular flap produced, one was two or three times the breadth of the papilla, and ran vertically; whilst the shorter, as one diameter of the latter, was horizontal, and formed a right angle with the upper end of the first. At some distance the thickened, shining, fatty-white borders of the irregularly lacerated retina could be seen, for some distance concealing the red choroidal ground from view. From the other side of the external margin of the rent to the region of the ora serrata the retina was detached in the form of a wrinkled bladder. The vitreous body was at the same time slightly opaque. Subjectively the affection was marked by a considerable impairment of the acuteness of vision, and an extensive narrowing of the visual field. ("Stellwag Lehrbuch," 4 Auflage, page 322.)

In one case, which Aub reports, from Knapp's clinic ("Arch. of Ophth. and Otol.," Vol. II. No. 1, p. 191), the left eye of a boy, aged fourteen, had

been struck by a piece of wood. Fourteen days later, on extreme mydriasis, a gap which ran upwards and backwards, and the margins of which were pigmented, could be seen at the junction of the choroid with the ciliary portion. Subsequently, resorption of the blood, extravasated into the vitreous humor, having taken place, an isolated rupture of the choroid manifested itself, in the region of the macula lutea, with two processes directed up and three directed downwards. The rupture in the anterior part of the fundus oculi had by this time become filled with cicatricial tissue, but the margins were still pigmented.

Knapp (*op. cit.* Vol. I. No. 1, p. 182, Figs. 6, 7, Tab. 2) contributes a description of, and a picture of an eye which had been wounded a year previously by the discharge of a pistol filled only with powder. The cornea and sclerotic contained numerous grains of powder. The patient could count the fingers only at the distance of one foot; the field of vision was considerably contracted on the nasal side. Movable opaque spots of the vitreous, which were seen on ophthalmoscopic examination, somewhat darkened the fundus of the eye. Nevertheless the examiner was enabled to see a curved white streak encircling the lower and outer sides of the porus opticus, and in the most anterior regions of the fundus, also downwards and to the inside a number of irregular white spots were seen, which could easily be interpreted to be denudations

of the sclerotic coat and defects of the uvea. The larger choroidal vessels were intact at these localities, and the retinal vessels passed over them without marked deviations; at one place, however, the retina was detached as a bluish oval vesicle.

These three cases have the remarkable feature in common, that the posterior choroidal rent was noticed to occur in the same meridian in which the eye had been forcibly struck anteriorly. They bear testimony against the origination of posterior choroidal rupture by contre-coup as well as by counter-pressure (according to Berlin), which may serve to justify my communication of the abstracts of these cases in this place.

Prognosis and Treatment.—The traumatic reaction may become very severe, but in average cases it is slight. The treatment consequently is in the beginning identical with that of hæmophthalmus posterior. Later, especially when retinal inflammation takes place, protection from full daylight and refraining from all accommodative activity of the other eye should be continued for weeks; a corresponding regulation of the diet will also be necessary.

In most cases, the visual power is immediately limited to quantitative light perception; in some cases this could be noticed only after from one to two weeks; such cases, where the returned visual power reached nearly or entirely the previous perfection, are to be considered as exceptions. At the

site of the rent a blind spot frequently remains; in others more or less limitation of the visual field occurs simultaneously. This is less frequently due to laceration of the optic nerve fibres than to reactionary inflammation, with or without consecutive retinal detachment (by cicatricial contraction). The functional integrity of the eye may be also interfered with permanently by new connective tissue formations in the vitreous humor.

§ 10. *Concussion of the Crystalline Lens* as a result of violent blows, pushing, whip-cuts, etc., or in consequence of forcible concussion of the cranium (or the whole body), very rarely causes *rupture of the anterior capsule* and its sequelæ (§ 24), except in such cases where the lens has been hurled towards the sclerotic rent (§ 4). Knapp (*l. c.*, p. 173) has seen an isolated *rent in the posterior capsule* after a blow on the eye, and Aub (*op. cit.*, Vol. II. No. 1, p. 192) observed a similar one in the case of anterior and posterior choroidal rupture cited above.

Much more frequently a partial or total stretching of the *suspensory ligament of the lens* or the zonula of Zinn results.

A man, aged thirty-five, was injured by a discharge of small shot. Immediately after, two grains of shot were removed from the forehead, four from the upper lid, and one from the external part of the conjunctiva. Four days subse-

quently, Aub found the upper lid swollen, with traces of the shot, of which latter none had perforated the lid (*loc. cit.*, p. 196). The sclerotic and palpebral portions of the conjunctiva were reddened and somewhat swollen; there was considerable circumcorneal injection, the cornea itself clear, bloody serum in the anterior chamber, pupil contracted; the iris showed a greenish discoloration, with bulging forwards of about one-sixth of its upper and external circumference. The details of the background of the eye were not discernible.

The pupil was dilated somewhat by atropine, and the lens was found to be uninjured, but pushed from its normal situation towards the upper and external portion of the cornea, thus causing the prominence of the iris. The vitreous humor was very opaque, and prevented an accurate investigation. The fingers could be counted only when within four feet, while the field of vision was perfect. Ocular tension was somewhat diminished. Pressure on the upper part, near the equator, was painful, but no injury could be discovered as the cause of this sensitiveness. After three days the eyeball was almost white, the cornea clear, the anterior chamber free from blood, the color of the iris normal; the pupil was dilated, *ad maximum*, by atropine, but the upper and external segment of the iris was still bulged forwards by the lens. The individual parts of the ocular background could now be distinguished, and were, with the

exception of a slight hyperæmia, normal. The patient exhibited a very curious metamorphosis. The upper and external end of a straight stick, when held diagonally before this eye, appeared thicker, while the lower inner extremity appeared thinner. If the stick was then turned around the line of vision, this abnormal appearance gradually decreased and finally vanished altogether, when it was held at a right angle to its original position. The fingers could be counted, at the distance of twelve feet, without glasses, and with a concave cylindrical glass of 20 inches focus, the upper end of its axis turned about 20° inwards. $S = \frac{20}{100}$. After the sixth day the eye was free from all inflammation, the crystalline and vitreous humors were clear, and the iris had lost the prominence before mentioned. The metamorphosis had disappeared. With cylindrical glasses, even with the weakest, he saw much worse, while with spherical concave lenses, $S = \frac{20}{30}$; without lenses of any kind, $S = \frac{20}{50}$. The application of atropine and mercurial inunctions were now suspended, and twenty-four days after the injury, the sharpness of vision was equal to $\frac{20}{20}$, his refraction emmetropic and accommodation perfect.

Aub now remarks that the prominence of the iris might be explained by an incomplete dislocation of the lens; but he decided in favor of a rupture or a relaxation (stretching) of the zonula, which allowed the lens to approach sphericity in the

corresponding region.¹ As the dislocation of the lens did not suffice to explain the metamorphosis, we might add, that, in this case, the accommodative power never would have regained its normal extent. "The optic system had become myopic in the outer and upper portion where the swelling of the lens occurred (as a direct result of the distension and slackening, or the laceration of the zonula at the same locality), and appears to have here more or less perfectly assumed the form and action of a conical lens, whose axis passed from above and outwards to below and inwards."

Provided we accept the facts and their explanation as correct, we are justified in the belief that partial stretching or laceration of the zonula can take its course without causing permanent damage.

Whether concussion of the eye, provided neither rupture of the capsule nor laceration of the zonula takes place, can directly occasion *opacity of the lens*, no reliable observations are extant to decide; but it is usually so considered. The opacity of the anterior cortical substance which Berlin (*loc. cit.*, p. 47) occasioned by striking the eyes of rabbits with an elastic rod, speak, it is true, in favor of the direct causation of cataract by concussion of the eye.

When unilateral cataract is observed to take

¹ Compare §§ 11 and 12.

place, more or less time after the injury by which the eyeball was contused, such cataract, occurring even without any lesion of the capsule and zonula, may have been caused by the rupture of the choroid, as the immediate result of the injury; that is to say, by the mediate influence of hemorrhage, or through the consecutive choroiditis or retinitis, and consecutive retinal detachment. It has been known for a long time, that with these very cataracts, following a contusion, which perhaps the patient, only after considerable inquiry, recollects as having taken place, amaurosis and amblyopia are often found, which are due to changes in the choroid or retina (by the contusion, perhaps, also, by a coincident perforating foreign body of small size not recognized on the examination), and the etiological connection between inflammatory choroidal affections and cataract, more particularly between retinal detachment and the latter, which has in recent times been clearly established.

In many of the cases of unilateral cataract belonging under this head, such an indirect causation may be suspected from the appearance of a certain discoloration of the iris, although the fibres may be clear, and from partial or total dilatation of the pupil. Synchrony of the vitreous humor, with unaltered position of the lens, points still more clearly to the above-mentioned causation of the cataract. Posterior synechiæ, form-

ing without circumcorneal injection or pain, are of frequent occurrence, and accompany cataract resulting from retinal detachment, whatever be the origin of the latter.

These synechiæ are not to be confounded with *irregular accumulations of pigment in the anterior capsule*, which are found, since *Beer* called attention to them, following several cases of injury with concussion of the eye-ball, even where no interruption of continuity took place in the iris or zonula, nor any preceding iritis was demonstrable.

To discover the causal connection under consideration in special cases, the examination of the perception of light, the field of vision, and the palpation of the globe are of inestimable value. In cases of cataract, due simply to direct injury or concussion of the lens, the field of vision and the tension of the globe would be normal.

§ 11. *Stretching and Laceration of the Zonula.*—

In order to appreciate the changes which take place near the zonula and on the lens itself as the result of concussion, we must first make the great importance of this delicate structure the subject of a brief consideration.

It is the zonula which fixes the lens in its position in the patellar fossa or depression of the vitreous; the immovable coaptation of the posterior capsule to the vitreous humor is relaxed as soon as the zonula has either in its whole or greater

circumference ceased to fix the lens to the ciliary processes. By reason of its breadth between the insertion at the margin of the anterior capsule, and the apices of the ciliary processes, it enables the lens to make anterior and posterior excursive motions without detriment to the union of the latter with the vitreous humor. Even lateral motions are thus permitted, although these do not occur in the physiological condition. The lens may move forwards for two or three millimetres (supposing the aqueous humor to be exhausted), and probably as much backwards, when the vitreous humor escapes or shrinks, and all this without laceration of the zonula, provided that the impulse is not too sudden.

The zonula can be stretched to an extent of two millimetres, perhaps even more, without rupture of its continuity, provided the tension is gradual. We see this in excessive degrees of myopia, and in the so-called buphthalmus as well as in staphylo-matous ectasia of the globe in the ciliary region; we find it in eyes with a concentrically shrunken lens, or a lens drawn forwards to a corneal cicatrix, and finally we are able to demonstrate such partial stretching with congenital ectopia lentis. (See § 14.)

With the existence of such a stretching, a more or less complete, respectively a total, laceration of the zonula can occur, with or without slight provocation; for instance, with bending or falling of

the body, or with concussion of the body or the head. While therefore in one case an existing luxation of the crystalline lens can be only attributed to a violent blow, whip-cut, or push, in another it may be explained by the peculiar organization of the injured individual, respectively of his eye. One will consequently, before giving an opinion on the force employed in producing an injury, endeavor as nearly as possible to find out the condition of the eye before the injury. Congenital ectopia of the lens, which greatly disposes to complete separation of the lens from its natural attachments, manifests itself not merely by short and weak-sightedness, but also by its, according to our experience, almost constant bilateral occurrence. Extreme myopia, also usually bilateral, though occasionally unilateral, can also be detected after an injury, at least when the latter has not caused a perforation of the sclerotic.

§ 12. *Diagnosis of Subluxation of the Crystalline Body.*—The zonula, by means of its tension, which, through the action of the ciliary muscle in accommodation and to see in short distances, can be diminished, presents an obstacle to the tendency of the lens to assume a spherical shape, and preserves it to a certain degree in a flattened condition. Where this tension is wanting on account of extensive or complete laceration of the zonula, the lens decreases in its equatorial, but increases

in its axial diameter. Therefore, in case of subluxations of the lens, *the eye is myopic*, and an advance of the lens towards the cornea can only serve to increase the myopia.

With the complete and extensive destruction of the zonula, *an essential factor of the accommodative power is suspended*; there is then only a certain defined distance in which the object must be brought on the line of direct sight, in order that the rays passing from the object to the retina may be brought to unite on the latter.

As soon as the lens is no longer held in place by the ciliary process, it is thrown into oscillations by the ocular motions; these oscillations are transmitted to the iris, and after sudden check following any extensive motion of the eye, produce *a trembling or undulation of the iris*. This symptom has in itself, however, no positive value, as in cases of transparent lens we cannot with certainty decide whether the oscillations of the iris are produced by a movable lens. The iris can be thrown into such motions independently when its pupillar margin is free and more aqueous humor has accumulated behind it than is normally found in that situation. In myopia, with a deep anterior chamber, we can frequently observe such oscillations of the larger circle of the iris, and in softening of the vitreous with a deep position of the lens we find such motions of the iris in a high degree.

§ 13. *Obliquity of the Crystalline Lens.*—After partial, and, under certain circumstances, often complete laceration of the zonula, the crystalline body may remain lying in front of the patellar depression for some time with little or no deviation of its axis from the optic axis; *usually, however, the crystalline lens assumes an oblique position* in such a manner that it protrudes further forwards with some part of its margin, and at the same time deviates more or less in the lateral direction, so that the more posterior portion of the margin lies nearer the ciliary processes than it did previously.

From this result, besides the changes enumerated in § 12, not only more or less considerable depreciation of vision on account of irregularity of refraction (astigmatism) takes place, but also an appearance of great diagnostic value, namely, the *unequal depth of the anterior chamber*. That portion of the margin of the lens which is pushed forwards, in its turn pushes the iris forwards.

The obliquity of the lens can at times be recognized, when considerable mydriasis, either pathological or artificial, is present, by the possibility of *seeing past the side of the projecting margin into the fundus oculi with the ophthalmoscope*. The margin itself then appears as a *dark meniscus*, as the light reflected from the background becomes cut off from the observer by its *total reflection at the border of the lens*, while not only through the lens

(as long as it is transparent), but also through the gap between the ciliary processes and the lenticular margin, the background appears red; provided always that neither hemorrhage nor its consequences nor retinal detachment are present.

§ 14. *Lateral Displacement of the Crystalline Body.*

—By reason of the total reflection of light which falls on the margin of a transparent lens, with capsule intact, and which is reflected to the observer's eye, a corresponding portion of the same appears as a *shining meniscus*, so that we are involuntarily reminded of a drop of oil floating on water. This phenomena can be observed, with the unaided eye, on assuming certain positions towards the lens (provided it is so far dislocated that the iris does not impede the view), when the lens enters the anterior chamber, or if part of its margin behind the iris lies in the pupil; or with the ophthalmoscope only, where the lens has been pushed, or has sunk into the vitreous humor. In the latter case it may happen, also, that the patient states that he sees a dark ring or a dark disk, somewhat lighter in the middle, before him, in cases in which, when the position of the lens and the conditions of the entrance of light combine in such a manner, that by reason of the complete reflection of the light falling in at the margin the part of the retina lying behind is shaded.

If the lens, not deprived of its capsule, and retaining its transparency, is dislocated in such a manner that it covers only a part of the pupillary region behind the iris, it may *cause the patient to have monocular diplopia*. Should such a lens, for instance, be so deeply sunken behind the iris that its upper margin would pass through near the middle of the pupillary region, the upper part of the rays of light coming through the pupil from a distant luminous object would produce a blurred image; the lower part of the rays, on the other hand, would pass through the upper part of the lens, and therefore be brought to a focus before the retina, as in a myopic eye, and at the same time deflected downwards, as this portion of the lens acts as a prism with its base directed downwards. The rays which traverse the lens will consequently produce another blurred image below, and the patient will therefore have the impression as if a second image were present above the other. It is true that by an adequate approaching of the object we would find a certain distance, in which the rays passing through the lens would be brought to a focus not in front of but upon the retina, and conversely the diminished refraction of the upper rays could be replaced by the employment of a convex lens. The pre-existing condition of refraction, respectively the structure of the eye before the injury, would have, naturally, to be considered in the examination.

Prognosis and Treatment.—In any case the subluxation of the crystalline lens results in a permanent disturbance of vision, which in even the most favorable case renders the occupations of reading, writing, sewing, and such like, which require accurate vision, impossible. It causes, sooner or later (even after years), either by itself or through changes in the choroid and vitreous humor opacity of the lens, or it gradually passes into the condition of a complete luxation. (Compare §§ 16 and 17.)

It is not probable that rents in the zonula, which have once resulted in obliquity or even displacement of the lens, should ever heal in such a manner that the latter regains its normal position and attachments. It is also not probable that the sequelæ can be avoided with certainty by dietetic prescriptions. It would be transgressing the limits of this article to explain under what circumstances the condition of the injured individual can be afterwards rendered a tolerable one by iridectomy, iridesis, or removal of the lens.

§ 15. *Luxation of the Lens.*—The crystalline lens when separated from all its attachments may present the same conditions as one still fixed in part to the ciliary processes by the zonula and simply placed obliquely, or at the same time more or less displaced laterally; as a rule, however, it

undergoes sooner or later a more considerable change of position, if this has not already been caused by the injurious act itself. There are also cases where an originally incomplete luxation passes, without further provocation, or after a renewed shock, into a complete one.

The completely luxated crystalline body may retain its transparency for weeks, months, and even years. Should it have suffered a considerable change in position, or have gradually passed into such, we will find it in the lower part of the *vitreous humor*, which in that case will have become liquified, or in the *anterior chamber*, or impacted in the *pupillary aperture of the iris*.

In one case which I saw, following a blow over the left eye, the lens was pushed upwards and inwards and pressed against the iris; at the same time the pupil was as strongly dilated as after atropinization, so that the background of the eye could be indistinctly seen through a meniscus situated below and without. In this case, the luxated lens was exceptionally immovable, and the eyeball was harder. The fingers could be counted only at the distance of five feet, through a small slit in a dark plate, and Jäger, No. 10 only could be recognized. Other changes could not be discovered.

It may also pass from any one of the positions mentioned into any other; it may alternately be

situated before or behind the iris.¹ The accidents occasioned thereby, excepting the dioptric disturbances, may be very slight, even for years, but they may also cause amaurotic blindness, obstinate inflammation of the uveal tunic, and even suppurative destruction of the eyeball. That the lens (usually without its capsule) may pass below the conjunctiva through a sclerotic rent, and still remain in the eye in the neighborhood of the ciliary rent, has been already remarked in § 4.

§ 16. That the *crystalline lens lies in the anterior chamber*, is readily recognizable when transparent by its pale-wine yellow color and the reflection of its margin. The lens never completely fills the chamber, although it pushes the iris backwards. Compare §§ 11 and 12. If the lens has become opaque, and has perhaps, many years after the luxating trauma, fallen into the anterior chamber, it is usually much diminished in size by fatty metamorphosis and calcareous deposit on the inner surface of the capsule and becomes irregular, spherical, or placenta-shaped. Again, it may be

¹ I observed for a considerable period a carpenter with submersion of the transparent lens into the vitreous body, who, when he was desirous of reading, held the book closely to his chest, in order that, by directing the axis of vision downwards, the lens could lie behind the iris, and so permit of vision at short distance. (Arlt. "Diseases of the Eye." Prague, 1856. III., p. 5.)

free and movable, or impacted and united to the cornea or to the iris.

If the lens was already opaque at the time of its prolapse into the chamber, the patient will not only have noticed the functional disturbance, but also the white opacity in the pupil. The *diagnosis* can therefore in no case be difficult.

Prognosis.—The lens lying in the anterior chamber can become dull and smaller in the course of time but it is never absorbed entirely. If it remain a long period lying on the floor of the chamber, and consequently in juxtaposition to the cornea, the corresponding part of the cornea becomes gradually opaque, and this opacity never clears up even after a perfectly successful extraction. It has been also observed that the corneal segment in question underwent a gelatinous softening in time, and that the cornea in such a case was destroyed by ulceration. Although such lenses may be carried around frequently for years without causing special inconvenience, it does happen in many cases that they incite an insidious iridocyclitis, with more or less severe paroxysms of pain. This first results in an increased serous exudation into the space previously occupied by the lens, then in an inflammatory softening of the zone of the sclera corresponding to the ciliary body, and pear-shaped metamorphosis of the eyeball as the thinned and expanded scleral region permits a moving forwards of the corneal basis, either in its half or entire

circumference. It may further result in serous exudation into the vitreous humor, in increased tension of the whole globe, and in glaucomatous amaurosis by pressure (excavation of the papilla). The lens may, nevertheless, reach a high degree of calcification without serious detriment to the posterior region of the globe. In the first years of my practice I extracted, by the flap incision, an almost completely calcified lens which had lain for years in the anterior chamber of one eye of a musician, so that he could walk around without a guide after this (his other eye was phthisical). Cataract-glasses were of little use to him, probably on account of a corneal opacity in the centre of that membrane where the cataractous lens had touched it.

Treatment.—Prolapsus of the crystalline body, that is, of the lens in its intact capsule, is a decided indication for extraction by the curved corneal section from below. It should not be delayed for a longer period than it takes for any coincident chemosis to pass off. The patient should assume a half-sitting posture in bed, in order that the lens may not retreat through the pupil. Whether the knife is to be passed before or behind, or perhaps even through the lens, the operator is usually not able to decide until just before transfixing. The best instrument is a small Beer's knife, as it causes the least dragging. The wound must permit of an easy exit, and when on the completion

of the section an exit does not take place, the lens must be removed by Daviel's scoop, a hook, or forceps. Pressure on such an eye may easily cause excessive loss of vitreous humor. For these reasons the extraction by means of the linear section would be too risky.

§ 17. *Sinking of the Crystalline into the Vitreous Body* may be under certain circumstances of easy, but with co-existing hæmophthalmus, of difficult recognition. If neither extravasation of blood, nor rupture, nor paralysis of the iris be present, such an eye is in all respects comparable to a purely *aphakial* one; the iris as a whole lies somewhat deeper, and strictly in one plane (which approximately occurs with only one other condition, *i. e.*, myopia), and exhibits after all rapid motions considerable iridodonesis; the pupil is narrow, and of a remarkably pure black, provided, however, the normally transparent lens lying in the vitreous humor does not cover a part of the pupillary area closely behind the iris. The lens, specifically heavier than the vitreous humor, lying as it does at the periphery of the globe, and usually in front of the equator, close to the *lower* wall, is displaced by every rapid motion of the eye; for instance, in suddenly looking upwards it will be thrown up and forwards to sink back immediately down and backwards. The patient, providing that no impediments exist to the entrance

of light or on the part of the retina, when lying on his back, perceives his lens by means of the *shadow which the latter throws on the retina*; he may even effect that the lens passes to behind the pupil by inclining the head forwards. Compare §§ 13 and 14. Finally, the transparent lens may be recognized by the reflectory phenomenon referred to in §§ 13 and 14; the opaque lens, through the *ophthalmoscope*, by its size, form, and color, when the other media are sufficiently transparent and the pupil dilated. The absence of the reflected images of Purkinje will be additional proof for the absence of the lens immediately behind the iris.

Prognosis and Treatment.—If the eye has suffered no other damage it may functionate for years in the same manner as an aphakial one. It may, however, by frequently repeated irritation of the iris and ciliary body be subjected to an insidious inflammation with serous exudation and loss of sight by glaucoma. The crystalline body may become wedged half way into the pupil on its way to the anterior chamber, from which situation it must be removed at all risks, if we wish to avoid seeing the eye destroyed by severe inflammation. Pro-lapsus into the anterior chamber is the consummation most to be desired, in order that extraction may become feasible. Extreme mydriasis and repeatedly tapping against the eye with pupil directed downwards (by flexing the head forwards), may enable

this prolapsus to occur, after which we will endeavor to keep the pupil contracted by the energetic use of Calabar bean. We should then proceed to carry out the extraction, but must be prepared, however, for more or less loss of the vitreous humor. The operation of discission while the lens is in the vitreous space is, if not impossible, at least extremely difficult and hardly less dangerous, as regards escape of the vitreous, than the method of extraction. Compare § 29.

§ 18 *Participation of the Retina in Contusion or Concussion of the Bulb.*—Not only before but also after the introduction of the ophthalmoscope, even until very recent times, there was an inclination to employ the term “*commotio retinæ*,” as characterizing the transitory or permanent disturbance of vision, existing after such injuries, provided neither the external nor the ophthalmoscopic examination exhibited adequate changes, and no reasonable signs were present to refer the changes to within the cranial cavity. It was customary to consider this as due to either a minimal displacement in the relations of the retinal elements (probably the layer of rods and cones), or to some influence caused by the vaso motor nerves. To Dr. Berlin (*vide* § 1) is due the credit of having pointed out the untenability of this supposition and of pursuing the path of exact scientific investigation in this obscure field.

For those to whom the "Klinische Monatsblätter" of Zehender is not accessible, I will give a short extract from the original:—

"When we consider the various forms of retinal commotion with reference to their etiology, we must distinguish two principal groups: those in which the *margin of the orbital cavity was struck either alone or chiefly*; and those in which the eyeball alone was touched. I will not discuss those cases in which nothing definite concerning this point can be discovered, especially such of commotion by lightning stroke, or by a passing cannon ball, since the material for observation thus far accumulated is too meagre to allow of a decision, as regards the pathogenesis of these injuries. I also believe myself justified in not entering into a discussion on the hypothetical connection between amaurosis and injuries of the supra-orbital nerve.

"With reference to the first group, the majority of these cases are combined with such *brain symptoms* that we have every reason to accept a direct or an indirect lesion of the optic nerve, probably as usual on the central side of the optic foramen or of its centres. The absence of brain symptoms, however, does not exclude the possibility of a lesion of the optic nerve having taken place. I have thus far never observed a case belonging to this group, which, with continued

examinations, failed to exhibit ophthalmoscopic symptoms of atrophy of the optic nerve.

"We might presuppose a commotion of the retina with more plausibility where the eye has been *directly* and *solely* struck by the blunt force.

"This group of cases is divisible into two varieties, the first, in which the *disturbance to vision is of a high degree, and usually combined with disturbance of eccentric vision*, such damage being generally permanent or of long duration; the second, which simply exhibit an *inconsiderable impediment limited to central vision*, which usually disappears completely within a few days. . . . As a result of my extensive experience, I subscribe to the opinion of Knapp and Geissler, that *amaurosis, or any considerable disturbance of vision* following concussion of the eyeball itself, *without ophthalmoscopic changes, are extremely rare.*"

Concerning the displacement of the histological elements of the retina from their mutual position as an explanation of the slighter cases, it has been as little demonstrated in the case of the retina as in that of the brain and spinal cord, and as regards the hypothesis of a paralysis of the vasomotor nerves, Berlin could never, with the most careful examination and comparison, with the uninjured eye (both in patients and animals) discover any dilatation of the arteries or the veins. Berlin, as a result of the experiments to be hereinafter mentioned, came to the conclusion *that in all cases*

where following concussion of the eyeball, slight disturbance of central vision, without a disproportionate depreciation of peripheral vision, which soon underwent cure, took place, it was due to transitory irregular astigmatism. This conclusion was based partly on the obstinate refusal of the pupil against atropine, partly on the anatomical changes observed in the eyes of rabbits, after experiments on the same, in their anterior segment. "When a blunt body had struck the eyeball itself, without causing any considerable injury to the tunics, or their contents, we found immediately after the injury a moderate depreciation of central vision without any disproportionate amount of damage to eccentric vision, provided no epithelial abrasion or small extravasation into the anterior chamber had taken place. The acuteness of vision in the eight cases, observed by myself, varied between $\frac{1.5}{100}$ and $\frac{1.5}{40}$. At the same time we found, without exception, that there was severe episcleral injection, and an extreme resistance of the sphincter iridis against the action of atropine. About an hour later we saw a gray, cloudy opacity at a defined area of the fundus, which soon increased and became intensified by the coalition of smaller patches of opacity until it even became of an intense whiteness; this opacity was found in four cases around the papilla and macula lutea, twice on the outer side of the background, and, in two other cases, two large separated areas of the retina were

opaque; in these two latter cases one of these two areas appertained to the anterior half of the retina, and the other to the posterior. The dulness usually reached its acme in about twenty-four or thirty-six hours (on the average two or three days), when no traces of it could be found. On registering the acuteness of vision it was found that it did not matter whether the opacity was in the region of the macula lutea or eccentrically, and that the visual disturbance had, in all cases, considerably diminished, while the opacity was at its height or even increasing. The improvement of vision which, in the first twenty-fours, made such rapid progress, advances from that time more slowly, and when the ophthalmoscopic appearances have already undergone complete retrogression, a diminution of vision to one-half or one-third usually remains behind for several days. I have never seen a complete dilatation of the pupil result, even after instilling atropine during the first hours of the injury, even repeating the process from six to eight times. This excitable state of the sphincter iridis passes away, it is true, but it still, in however slight a degree, remains beyond the period when the ophthalmoscopic appearances have passed off. The same is true of the visual disturbance, and this latter seems to keep pace with the restitution of the former. I could never find any change in the tension of the globe."

In experiments performed on rabbits, ophthalmoscopic examination showed that when the force employed struck the sclerotic, extensive opacity became apparent in that part of the retina corresponding to the sclerotic area injured; but, besides this, there was another spot nearly opposite the former showing the same change. Anatomically the important discovery was made that the opacity was due to *acute œdema of the retina*, which was the result of extensive hemorrhage *between the choroid and the sclerotic, not only at the locality primarily injured, but also at the one indirectly implicated*. If the blow struck the cornea we find that besides sub-choroidal hemorrhage in the region of the posterior pole, *other hemorrhages of lesser extent always take place between the ciliary muscle or the anterior choroidal segment on the one hand and the sclerotic on the other*. "We frequently also, though not with the same absolute constancy, find hemorrhages into the canal of Schlemm, also between the pars ciliaris retinæ and the choroid, as well as circumscribed hemorrhages on the posterior wall of the iris."

As such, the sub-choroidal hemorrhage cannot cause any defect of vision, and this latter can, after what has been said above, be as little deduced from the opacity of the retina; for the latter, respectively, the choroidal hemorrhage may also be wanting in such cases within that part of the

retina accessible to the ophthalmoscope. Berlin saw two cases of "ocular injury by a blunt force, in which, in spite of the fact that the visional disturbance of the same degree and course, as in the above described group, was present, no changes could be found in the retina. Both cases, however, exhibited active pericorneal injection, and considerable resistance against the action of atropine, which excited condition, in one case, reached the degree of an iritis." "On the other hand, it is very probable that *hemorrhages in the immediate vicinity of the lens* (such were experimentally proven to exist), *can influence the shape, and even, under certain circumstances, the position of the latter,* and thus a disturbance of vision in conjunction with the spastic contraction of the sphincter iridis through irregular astigmatism." "The course and degree of this visual disturbance would tally very well with the supposition that the alterations in shape and position of the lens were due to small accumulations of blood. It would be especially the rapid improvement in the beginning which would have to be assigned to the more rapid absorption of the fluid constituents of the blood. In the same way it could be easily comprehended that the irritability of the iris and the visual disturbance should accurately correspond as to duration, if we believe that both attain their complete normal condition only after total absorption of the blood has taken place."

I have already stated, in the general observations "on compression and concussion," in § 1, that I cannot agree with Berlin concerning the ruptures of single vessels, or whole parts of the membrane, in the posterior portion of the choroid. To the general observations on compression and concussion in § 1, I will only add that the uveal ruptures of the anterior segment of the eye are attributable, in part, directly to contusion of that portion of the choroid just under the part of the sclerotic struck, and partly to flattening of the cornea and the momentary dilatation of the corneo-scleral ring, while the sclero-uveal rent, which runs parallel to the corneal margin, is to be regarded as resulting from sudden expansion of the bulb in that circle or ring, of which this rent just forms a small portion.

§ 19. We are still in the dark as to the etiology of *paralysis of the sphincter of the pupil* and of the *ciliary muscle* after powerful momentary contusion of the eyeball. After such injuries we find the pupil more or less dilated, perfectly circular or oval, the iris is immovable, not only under the influence of light but also with increased convergence of the visual axes and under irritation of the conjunctiva as well as of the cornea, with all of which, perhaps, no change of traumatic origin can be demonstrated either in the iris or the lens and its attachments, or in the retinal or the cho-

roidal tunics. As a separation in the continuity of the ciliary nerves is hardly supposable without a vascular rupture in some part or other, the supposition that an extravasation between the choroid and sclerotic, which acts injuriously by pressure, suggests itself as more plausible than stretching or laceration of the ciliary nerves; in actual choroidal laceration, however, the latter eventuality is at least probable, but its anatomical demonstration is yet wanting.

Paralysis of the sphincter of the iris and of the muscle of accommodation, if of traumatic origin and of higher degree, is incurable; if of slight degree only, it usually disappears again after a few days. In cases of the latter description, aromatic fomentations are said to have proved useful.

HISTORIES OF CASES.

1. TRAUMATIC SUBLUXATION OF THE LENS TOWARDS THE CENTRE OF THE VITREOUS BODY. EXTRACTION; CURE.

Six months before his admission to the clinique, a Hungarian shoemaker, fifty-four years of age, had been injured in the right eye by a stone (thrown). It seems that the hemorrhage from a slight cutaneous wound, as well as the reddening of the eye and the loss of visual power, had been inconsiderable for the first few days. The loss of sight be-

came considerable in the course of the following three months, and this induced the patient to come to Vienna. Patient strong and well nourished; eyes deep-set. The left eye healthy; the right, excepting a few dilated conjunctival vessels, exhibits none of the appearances incident to inflammation or irritation; the cornea normal, the pupil dilated to its maximum (iridoplegia); in the centre of the pupil the margin of the crystalline lens, which is dislocated upwards and inwards, is visible. The external half of the pupil is of a pure black. Behind the inner half of the pupil is situated the slightly opaque lens, of a smoky-gray color, excepting a narrow marginal zone, which appears clear and presents the reflection phenomenon very distinctly, is seen not only by direct light but also by illumination of the background. Ophthalmoscopic examination showed that the nucleus was slightly opaque. The crystalline lens, still attached above and inwards to the ciliary processes, oscillated plainly, even on very slight excursive motions of the eye, and its external margin retreated backwards for a distance, approximately, of 3-4 millimetres, when the head was flexed backwards. Tension of globe normal. Ophthalmoscopic appearance of fundus normal. With a lens of $+3\frac{1}{4}$, Snellen's test-types, No. 40, could be recognized at a distance of twenty feet, and No. 2 of Jaeger's could be read with a $+2\frac{1}{2}$ through that part of the pupil which was free from the lens. On the 27th

of May, 1873, extraction with the flat curvilinear section below was performed, the patient occupying a half sitting posture in bed. The lids were fixed by means of the fingers and the globe by the forceps. A curved reclination-needle was introduced, not below, but above the horizontal meridian, from the nasal side, in order to transfix the lens from behind, and thus to steady it. The lens being then slightly pushed towards the iris, and maintained in this position by a second assistant, the chamber was immediately opened, with a tapering Beer's knife (of 30 millimetres length, and a base of 5 mm.), by a corneal section about eleven millimetres long and a curve height of 2-3 millimetres. Daviel's scoop was then introduced, the lens circumvented from behind and drawn forwards, the needle at the same time being withdrawn. A bulging portion of the vitreous humor was cut away, and both eyes were bandaged. On the 16th of June the wound was completely healed, the eye quite pale and free from irritation, the pupil perfectly black, but drawn somewhat downwards. Vision, with $+3\frac{1}{2}$, Snellen, = $\frac{20}{60}$, with $+2\frac{1}{2}$ Jaeger No. 3.

2. TRAUMATIC LUXATION OF THE CRYSTALLINE LENS INTO THE ANTERIOR CHAMBER, PRE-EXISTING (CONGENITAL?) ECTOPIA OF THE SAME; CONSECUTIVE CYCLITIS WITH INCREASE OF TENSION. EXTRACTION, INCOMPLETE CURE.

Four weeks ago a woman, twenty-five years of age, in threshing, received a blow over the right eye with the flail. No reliable information as to the immediate sequelæ can be obtained; she believes herself to have had very good vision with both eyes, which evidently could not have been the case, as was afterwards determined. The pains in the eye and its vicinity disappeared under the use of cold compresses, but returned after a short period and never passed off entirely. Three very severe attacks in rapid succession caused her to seek relief. On her admission on the 16th December, 1873, we found the following condition of things: the right eye is closed, tears flow readily, there is photophobia, and there is also a dense net-like pericorneal redness, especially of the lower portion. The corneal base, especially in its lower half, is plainly pushed forwards, evidently on account of the contiguous sclerotic region being expanded in consequence of inflammatory softening; and for the same reason it is also of a violet-red with here and there a slate-gray color. At this locality the lower half of the cornea is dull, with slightly diffused opacities; the iris hardly

exceeds two millimetres in breadth ; between the two lies the pale-yellow, transparent, crystalline lens, decreased in its equatorial, and increased in its axial diameter, therefore rather more spherical than lenticular in shape. Between it and the pupillar margin above we can look into the fundus. At the margin of the lens the well-known reflection can be seen. The globe does not feel harder on palpation, but is very tender to manipulation near the ciliary region. Fingers are counted at a distance of about four feet, the light of a candle flame is appreciated at ten feet. On December 17th extraction with a narrow Beer's knife, the section being between nine and ten millimetres long, with a height of the flap of about two millimetres. In applying the scoop of Daviel, in order to extract the lens, the latter rapidly made its exit, together with some liquefied vitreous humor ; and on this account the bandage was applied immediately. The lens had an equatorial diameter of four and a half millimetres, and an axial one of three millimetres ; the capsule was intact. On examining the condition of the wound, on the 18th and 19th of the month, its closure was found to be good ; on the 20th the flap was seen to be somewhat bulged forwards ; the iris was in contact with the corneal cicatrix ; the latter, however, was somewhat expanded, and consequently the lower half of the cornea ascended towards the cicatrix like the cornice of a roof. This latter condi-

tion changed but little up to the day of discharge (January 7th), when the patient was only able to count fingers, at a distance of twelve feet at most, by the aid of a horizontally held slit of the stenopaic apparatus. This was due in part to a slight corneal opacity at the spot with which the lens had been in contact. The thorough examination of the background was rendered difficult, partly by this opacity, and partly by the altered curvature of the cornea; and the only fact which could be elucidated with certainty was pressure-excavation of the optic disk. I have related this case chiefly because, not satisfied with the statements of the patient as to the origin of the prolapse of the lens into the anterior chamber, we had latterly dilated the pupil of the pretended healthy eye with atropine, and could readily satisfy ourselves that the lens was displaced upwards. This individual, therefore, certainly had (congenital) ectopia of the crystalline lens in both eyes. In the absence of an examination of the left eye, the injury to the right one would have been incorrectly estimated.

3. TRAUMATIC DISTENSION OF THE ZONULA; CHANGE IN FORM AND POSITION OF THE LENS; MYOPIA.

A blacksmith, forty-two years of age, while wielding his hammer, slipped and struck his left eye with his fist. Failure of vision was noticed

shortly afterwards, and as it continued, he eventually came to the hospital on the 19th day after the accident. We found the right eye normal. The conjunctiva bulbi of the left eye was tinged yellow below, the result of previous extravasation; the cornea was intact, the chamber was remarkably smaller than upon the right side, by a regular protrusion *in toto* of the iris forwards, the iris reacted feebly, was of a greenish color but without any trace of inflammation, the pupil was somewhat larger than on the right side, and is not perfectly circular; there were several flakes of pigment on the capsule; and there were no oscillations either of the iris or the lens. Fingers were counted within 18 feet, with a lens of —6, Snellen No. 20 he recognized at 40 feet, with the unaided eye Jaeger No. 2 at 6 inches. The background could be plainly seen with —8. The right eye's vision with concave $36 = \frac{20}{XX}$ (Snellen). As we had no

reason to mistrust the man's statement, that he had previously seen as well with his left eye as with his right, we believed that the result of the examination could only be explained by distension of the zonula with advancement and increased convexity of the lens. Repeated examination was, we regret to say, not possible.

4. RUPTURE OF THE CHOROID AND RETINA AT THE POSTERIOR POLE, HEMORRHAGE INTO THE VITREOUS HUMOR AND IRIDOPLEGIA, PROBABLY ALSO SUBLUXATION OF THE LENS, FOLLOWING THE STRIKING OF A STONE AGAINST THE RIGHT EYE, REACTIVE INFLAMMATION, PERMANENT DEFECT OF THE FIELD OF VISION.

S. I., aged thirty-five years, was, on October 7th, 1873, so severely injured by a stone thrown against his right eye, that he lay unconscious for probably a quarter of an hour, bleeding considerably. After the ensuing swelling, which extended over the whole corresponding side of the face, had disappeared under the use of cold applications, and the eye could be opened, the patient noticed that he could not see with this organ. On the 24th of October we found a linear scar, nearly an inch long, extending from the external commissure to the middle of the upper lid. On the external corneal margin there was a shallow, sickle-shaped ulcer, and considerable conjunctival reddening corresponding to it; besides this there was a moderate degree of episcleral reddening all around the cornea. The aqueous humor was clear, the pupil, which was wider than that of the left eye, did not react to the stimulus of light, and on the use of atropia dilated more towards the nasal than towards the temporal side. The iris was tremulous during ocular motions; but whether the

transparent lens took part in these movements could not be determined. Upon the capsule several dots of pigment were seen, and with the aid of the mirror large masses in the shape of dots, flakes, and membranes, without any decided admixture of blood, were seen undulating in the vitreous humor; retinal detachment could nowhere be discovered. Adjoining the papilla, a considerable accumulation of blood had taken place. The fingers could not be counted, and only motions of the whole hand were appreciated. Quiet and ice-cold compresses were ordered, and the patient placed in a moderately darkened room.

On the 3d of November the vitreous humor had so far cleared up that the background of the eye could be distinguished. The papilla seemed to be slightly veiled and pale; its vessels partially filled and narrow.

The principal changes were found on the temporal side of the optic disk, and surrounded the latter for two-thirds of its circumference, with somewhat arched processes running up and downwards. From the papilla to beyond the macula lutea we saw a bluish meshwork with a whitish reflection and oval gaps in which either blood or pigmentary accumulations were lodged. This mesh work, which evidently passed through the vitreous humor, and in front of the retina, was clearly composed of connective tissue and covered a space, equivalent to four times the area of the

optic disk, as it sent processes upwards and inwards from its focus which corresponded to the region of the macula. The trabeculæ covered several of the retinal vessels. One of these trabeculæ could be traced from below and outwards to the entrance of the vessels, while a second, a much larger and broader one, covered the ascending retinal vessels. Below the disk, at a distance equivalent to about one-half of its diameter, was seen a light yellow conical streak, which appeared at the lower margin of the newly formed connective tissue; in its course inwards, it was bridged over by a retinal vein immediately under the disk, and terminated in a sharp point a considerable distance from the latter. This streak could hardly be construed into anything else than a branch of the choroidal rent. Its margins were suffused with blood. An exactly similar streak also came from underneath the connective tissue framework, closely to the former, and terminated like it in a sharp slit-shaped point, after running a course tending directly downwards, and being likewise half way bridged over by a retinal vein. The centre as well as the upper part of the choroidal rent appeared to be hidden beneath the connective tissue bands mentioned. At this time flocculi of blood could be distinctly seen in the vitreous humor.

CHAPTER II.

PENETRATING WOUNDS OF THE EYE.

(A.) *The foreign body not remaining in the Eye.*

§ 20. *Wounds of the Conjunctiva* when they are not on the fornix are usually easily recognized, and are never of serious import, whether occurring alone or in connection with other injuries.

At first its solution of continuity reveals itself by hemorrhage, bloody suffusion and tumefaction of the margins, which when they gape considerably, expose the sclerotic. Later, after powerful reaction, or after actual loss of substance, a light grayish layer forms on the wounded surface, beneath which granulations develop. These either serve to unite margins of the wound, or project more or less above the surrounding surface; in the latter case gradually becoming narrower at the base, until finally they are attached only by a delicate pedicle, when they can be readily removed with scissors. An application of lunar caustic, made when their base is broad, will require frequent repetition. The resulting cicatrix may be linear or radiating, in the latter case being always closely attached to the sclerotic. It is only in cases where the loss of substance has been con-

siderable, and much of the neighboring conjunctiva had to be drawn towards the wound in order to cover it, that the mobility of the eyeball, or the passage of tears, may be impeded. Sometimes there is no visible cicatrix left.

The *prognosis and treatment* are easily determined from what has been said, and upon the general principles of medicine. In cases of wounds implicating both the palpebral and the opposite part of the bulbar conjunctiva, our attention should be directed to the prevention of symblepharon. Compare §§ 36, 37. One point I would especially refer to, and that is that we are no longer timid in applying sutures to widely-gaping conjunctival wounds, which are employed with the best results.

§ 21. *Wounds of the Conjunctiva, with either partial or complete division of one of the Recti Muscles,* are not difficult to diagnose; they are apt to interfere with the free mobility of the eyeball, and to give rise to secondary divergence of the eye and diplopia. In recent cases we should endeavor to prevent these results by the use of a deep conjunctival suture; in older ones we might expect some benefit from an advancement of the injured muscle, which had become attached too far backwards to the sclerotic or the tunica vaginalis.

§ 22. *Penetrating wounds of the Conjunctiva and Sclerotic* are usually complicated with prolapse of

the vitreous and injury to the ciliary body, and are, therefore, of the greatest importance. See § 4, and *d*, page 104.)

Recent penetrating wounds of the sclerotic are recognized by the decreased tension of the globe, by the visibility of parts of the uveal tunic (especially its pigment), and by extruding vitreous humor. The cicatrices are characterized by firm adherence of the conjunctiva to the sclerotic, by pigmentation and radiatory retraction. Very small wounds may not leave any appreciable trace at all. Extensive wounds of the sclerotic may become fatal to the eye through profuse loss of vitreous humor, or extreme intraocular hemorrhage. In other cases, they threaten danger to the uninjured eye by sympathetic cyclitis. There are also cases, especially after penetrating wounds situated far back, in which, after an apparently favorable course of the cicatrization, a gradual, often conical, retraction takes place, which leads to limitation of the visual field, and finally even to total blindness. This latter is, as Graefe has shown ("Archiv für Ophth.," III. p. 391), produced by retinal detachment, in consequence of the dragging of the retina towards the scleral cicatrix; while in other cases it is occasioned by the shrinking of membranes that have been found in the vitreous humor.

It is, therefore, never advisable to give a definite opinion as to the gravity of a penetrating

wound of the sclera, especially when it implicates the retina, before several months, at least, have passed without subsequent further damage, and especially without retraction of the sclerotic. The union of long scleral wounds by suture, as practised by Windsor, Bowman, Lawson, and Thos. R. Pooley ("Allgemeine Wiener Med. Zeitung," 1874, No. 8), provided it can be accomplished without further loss of vitreous, may be regarded as an improvement in the treatment of these wounds; otherwise, it will be necessary for the patient to keep quiet a long time, as well as to carefully apply the protective bandage (§ 23).

§ 23. *Wounds of the Cornea* and their immediate sequelæ, are at times easy of recognition; at others they are recognizable by certain methods of investigation only.

Diagnosis.—If we observe the image of a distant window reflected from various parts of a cornea, we can readily recognize the slightest depression or elevation of the corneal surface. Small bubbles of foam, which are produced by the movements of the lids, from the oily secretion of the Meibomian glands and the lachrymal secretion (originating in an analogous manner to soap-bubbles), are easily distinguished from permanent elevations of the corneal surface by their inconstancy and mobility.

If we cause the light of a candle-flame in a dark

room to fall on the cornea from a distance of about one foot, through a convex lens (of a focal distance of from 1-2 inches), beginning by holding it nearer to the cornea than its focal distance amounts to, and in such a manner that the axis of the lens coincides with the straight line which is supposed to combine the flame and the cornea, we obtain a light disk on the surface of the eyeball, the luminous intensity of which increases with the increased distance of the lens until the focus coincides with a point on the surface of the cornea. In this way every dull spot on the cornea becomes visible, which spot, in ordinary illumination, might escape the unaided eye. Since the introduction of this mode of examination, *the lateral or focal illumination of Helmholtz* ("Archiv für Ophth." I. Vol. 1, A. 74), we know that the finest punctured wounds of the cornea do not heal without leaving some trace (as in keratonyxis, for capsular discission).

Without employing the reflected image of the cornea, and without artificial focal illumination, no reliable opinion can be delivered as to the convexity or transparency of the cornea.

In examining *recent corneal wounds*, we must, before all other things, determine whether the wall of the eyeball, that is, the cornea itself, or the neighboring part of the sclera, is perforated or not. *Symptoms of perforation* are: absence or diminution of the depth of the anterior chamber,

with decreased tension of the globe; contact of a part of the iris with the wound; prolapsus of the iris in wounds of the corneo-scleral margin or of the vitreous humor, with displacement of the pupil towards the wound. Thread-shaped or conical connections between the anterior and posterior walls of the chamber, as well as small traces of pigment of the iris on the cornea, mark the precedent perforation at a later period. They are, as a rule, only visible with focal illumination. Blood in the anterior chamber may point to injury of the iris; but it may also have been produced by the rupture of choroidal vessels. If the injuring instrument had reached to the pupillary region and perforated the anterior capsule, we would, even within a few hours, notice a cloudiness of the lens. If the perforating body had struck the iris, we would find a rent, a gap, or a coagulum in the latter.

Later, when inflammatory reaction, especially with suppuration, and more or less opacity of the neighborhood, has taken place, the questions as to the direction, shape, and depth of the wound of the cornea are at times not to be answered; and it may even remain doubtful whether the injury was due to the penetration of the injuring body causing direct solutions of continuity, or to contusion by sudden compression. (§ 3.)

Prognosis.—1. Wounds which, either directly or through ensuing suppuration, cause but a *super-*

ficial loss of continuity or substance, not extending as far as the membrane of Descemet, can heal without leaving more than a transitory opacity behind. This termination is to be looked for with the less likelihood the deeper the *loss of substance*, the more advanced the age of the patient, and the poorer his general health. The opacities thence resulting impede vision more by causing diffusion of light than by preventing the rays from reaching the retina.

Exposure of the corneal nerves by superficial loss of substance, usually causes severe and protracted pain; while their division, even in extensive wounds, as in the extraction of cataract, appears to be only slightly painful.

Abrasion of the cornea, or even shallow scratches, in which not only the epithelium but the superficial fibrous layers also are implicated, I have seen only as the result of accidental injuries, as in rubbing against a sprig of broom, or a comb, most frequently with a finger-nail (through careless mothers and nurses); I do not doubt that they may occur as the result of criminal acts. The excruciating pain caused by the exposure of the corneal nerves, the visual disturbance, pericorneal injection, blepharospasm, photophobia, and lachrymal flow, usually subside after a few days under the use of cold applications. The immediate incentive, however, which has frequently induced patients so injured to apply to me has been the

re-exacerbation of the same symptoms after weeks of apparent perfect recovery; even the thrice or four times repeated return of attacks lasting for days, and occurring at intervals of from five to eight weeks. If the pain exhibits any definite periodicity, we are apt to consider such exacerbations as due to a neuralgia; on repeated examination of the corneal reflections, however, we find the cornea abraded in some place, and it is only after questioning that we receive information as to its having been caused by some scarcely noticed injury. A woman, from the neighborhood of Krems, had become extremely prostrated by reason of her solicitude for her eye, after having four times suffered such relapses, lasting from eight to ten days each. It was only after repeated questioning that she recollected having been scratched by the finger-nails of her own child.

The trouble is easily relieved permanently if we retain the eye under a good protective bandage until *complete* restoration of reflection has taken place on the injured spot. Atropine is dropped in as the bandage is daily renewed. On the average this treatment must be carried out for one or two weeks.

2. *Deeply penetrating wounds*, even where they unite by first intention, always leave a persisting opacity. The influence which this has on the function of the organ, and on the personal appearance of the patient, depends upon its seat and ex-

tent. *Changes in the corneal curvature*, and consequent irregularity of refraction, are not so much to be feared after non-penetrating wounds. For some time, however, linear scratches may result in a rising of the margins of the wound, on account of their retraction, and diminished resistance to the pressure of the aqueous humor. This elevation is the more considerable the deeper and longer the wound, particularly when curved or V-shaped.

3. In many wounds *suppuration* is to be feared. The more decidedly the solution of continuity has been due to the sharpness of a conical or wedge-shaped instrument, the more favorable the prognosis, as contrasted with those cases in which the wound is more or less contused. With some wounds, suppuration is to be apprehended as a certain, or at least a probable, result. The more the solution of continuity is to be ascribed to the sharp (conical or wedge-shaped) character of the penetrating body, the more favorable is the prognosis in contradistinction to those wounds which are more or less contused. *Flaps, frayed edges, and serrae*, even without an accompanying perforation, impede union by first intention by their tendency to roll inwards, or to become everted. If, at the same time, foreign matters, acting either *mechanically or chemically*, have become lodged in the wound, such as dust, ink, or decaying substances; these foreign matters alone are sufficient to incite suppuration. In *aged and poorly nourished*

individuals, and in cases of *lachrymal obstruction*, the danger of suppuration is still greater. Finally, as is well known, a prospectively favorable termination may become changed *for the worse* through carelessness (uncleanliness, use of irritant agents, etc.).

A description of *corneal abscesses and their sequelæ* is not within the scope of this work.

4. Besides the points discussed under 1-3, the following circumstances deserve consideration in cases of *penetrating wounds of the cornea*:—

a. Penetrating wounds, which by their *shape and slight extent* permit a durable closure of the ocular capsule, or promise this closure in a short time, are incomparably more favorable than *long linear, arched, or V-shaped* wounds, for the latter admit the possibility of a considerable prolapse of the iris, causing extensive displacement, or even closure of the pupil, or of various changes in the corneal sphericity, and consequent irregularity of refraction, whether due to impaction of a part of the iris, or to retraction of the cicatricial tissue; tending, finally, especially when not in the straight linear direction, to elevation and suppuration of the corneal flap, and to general ocular inflammation with suppuration. (Phthisis bulbi.)

b. Penetrating wounds, which pass *obliquely through the cornea*, provided no flaps or frayed edges of considerable length exist, show less tendency to gaping than equally long wounds which

pass vertically through the cornea; that is, such rectilinear wounds, in the production of which the edge of the instrument was directed towards the centre of revolution of the corneal surface.

c. Penetrating wounds of the cornea which *solely cause prolapse of the iris*, still admit of a favorable prognosis, provided the pupil is not closed or displaced too much towards the periphery, and the corneal curvature not permanently changed. In similar cases, and even after the development of an actual partial staphyloma, the restoration of the faculty of vision is still possible by the performance of iridectomy; provided always that the other general conditions of such restoration are not absent. If the cicatrix covering a prolapse of the iris remains ectatic, the eye is not free from the danger of an earlier or later increase of tension, with glaucomatous blindness.

d. Penetrating wounds of the *corneo-scleral margin*, rank among the most serious injuries of the eye, even when they are not, as, however, is most frequently the case, complicated with protrusion of the vitreous humor or of the iris.

a. *Cystoid cicatrization*, with or without a visible strangulation of the iris, may result, by union simply of the margins of the conjunctiva, not of the corneo-scleral tissue. This superficial and non-resistant covering being bulged forwards, as a cyst, by the aqueous humor, with or without the iris.

This may provoke a permanent irritation of the ciliary body, and increase of pressure, perhaps also sympathetic cyclitis of the other eye, perhaps a further suppurative inflammation in the uveal tunic (purulent iridochoroiditis), and phthisis of the injured eye.

β. Now and then the later occurrence of *cystic formation* within the iris has been noticed, after apparently insignificant punctured and incised wounds of the scleral margin. Probably, in these cases (following Rothmund's plausible view, "Klinische Monatsblätter," 1871, p. 397) the wounding body had only penetrated to the peripheral part of the iris, and had carried some epithelial cells from the surface into its substance, and these may have stimulated the production of a thin walled cyst, the inner surface of which is usually found lined with epithelium. This development appears to take place without noticeable symptoms, and very slowly. Those afflicted with it (thus far nine such cases have been seen by myself) did not seek my advice before the cyst had extended more or less from the periphery into the pupillary region, and had produced some visual disturbance, and perhaps pain, also; ciliary injection and photophobia after a lapse, usually of years. The scar manifests itself as a white dot or streak on the corneal limbus, perhaps reaching to the sclerotic tissue. The contents of the cyst,

which might be mistaken for a cysticercus, or an atheromatous cyst, lying between the cornea and iris (Graefe "Archiv für Ophth.," Vol. III. 412), are pellucid, and, on account of the thinness of its walls, readily permit the transmission of light. The anterior part of the wall, which touches the membrane of Descemet in more or less extent, is composed of the anterior connective tissue layer of the iris, only occasionally bearing pigment near the pupillary margin; the posterior portion, which may produce displacement or opacity of the lens, is very dark and opaque, by reason of the large amount of pigment it contains. From the adjacent healthy part of the iris it is strongly defined by a constriction or groove. Vascular development is either wholly wanting, or is present only on the cornea in front of the cyst.

I have succeeded in every case but one, where the cyst had barely a diameter of three millimetres, in piercing the cyst from the corneo-sclerotic margin with a broad lance-shaped knife, thus causing the walls to collapse and become everted, thereby enabling me to seize them and pare them off. Other operators have opened the chamber close to the cyst, and then endeavored to draw it through. Return of the affection has often been recorded after this method of operating.

γ. *Cataracts* have been observed to follow wounds in this region, immediately or after a

longer period ; in the latter case, evidently because the equator of the lens had been injured, without its being immediately noticed. Such cataracts sometimes remain partial and stationary.

δ. The most dangerous penetrating wounds, without question, are those of the corneo-scleral margin, on account of the coincident *injury of the ciliary body*, in which consecutively an acute, or an insidiously protracted, inflammation is set up, which leads to the production of purulent exudation in the anterior chamber and the vitreous body, and not only causes the ruin of the eye concerned, but also readily results in sympathetic iridocyclitis of the other organ. The occurrence of the latter may frequently, though not in every case, be prevented by careful management on the part of the patient. Compare the article on "Sympathetic Ophthalmia," in the "Wiener Medicinische Wochenschrift," Nos. 5, 6, and 7, 1873.

e. *The injury of the iris* is of especial importance only in case of coincident *wounding of the crystalline body*. The results of the latter will be considered more at length in § 24. The same changes may also take place in the iris after wounds of the cornea, which follow sudden compression of the eyeball (§ 7).

Treatment.—In cases of fresh corneal wounds, provided other and more important indications are not neglected, no objection can be made to the

widely-spread opinion, that cold applications are to be made to every injured eye. At the present day there are probably few ophthalmologists who, after a cataract extraction—which is really an extensive corneal wound—immediately apply cold compresses, or even, as used to be customary, annoy their patients with ice compresses for days. Beer (“Compendium,” Vienna, 1799) said already: “Nature, without the surgeon’s assistance, heals simple wounds made with a sharp, clean knife.

The most essential indication to be fulfilled is the prevention of all palpebral movements, and, in case of penetrating wounds, the avoidance of all pressure, or, at least, of all unequal pressure, as well as the increase of any intra-ocular pressure caused by congestion attending sneezing, coughing, stooping, lifting, and such like movements. Where the condition of the lids permits (in case of their being also wounded), successive layers of charpie are placed in the depression between the nose and the supraorbital margin, or else charpie with underlying cotton. This is then fastened with a monocular bandage, composed of an elastic middle piece of fine flannel and two bands of tape at least a half an inch in breadth and each about three-quarters of a yard in length. The one end of the elliptic-shaped flannel strip, which is about nine inches long, and in the middle two and a half inches broad, is applied below the lobule of the

ear, and the other over the frontal protuberance of the other side, and the tapes are done up as in a figure-of-eight bandage. The immobility of this bandage may be secured by applying a circular, inch-tape bandage, passed around the occiput and forehead. The bandaging should be preceded by careful cleansing of the wound and the conjunctival sac, and, as a rule, by the instillation of atropine also.

Should a narrow strip of corneal substance, especially in case of lacerated wounds, project so far that we cannot expect it to reunite with the rest, it should be removed by scissors. The same is to be done with a flap of the iris when protruding from a wound. Vitreous humor, hanging from a wound, need not be removed, as it does not prevent union by first intention, and as it is gradually thrown off. In prolapse of the iris, it has been suggested by various observers to push the prolapsed portion back with a Daviell scoop, or a probe, because its retraction under the influence of Calabar bean, or atropine, cannot be counted on. This adjustment can be attempted with a prospect of success only when the conditions of the wound are such that we can expect a union after the removal of the iris. It should only be undertaken with a perfectly immovable eyeball, consequently, better under anæsthesia, as the capsule is liable to be wounded,

and, as we should not forget, the iris on any pressure readily reacts by inflammation.

If the prolapsed part of the iris, either sooner or later, assumes the shape of a blister or of a piece of strangulated intestine, with a narrow base, we should immediately proceed, the eyeball being fixed, to clip it off. When, on the other hand, the prolapse presents under the form of a round or longish prolapse, with a relatively broad base, we have reason to expect that its surface will be gradually covered by the development of connective tissue and be thus firmly held back. Should this cicatricial tissue not suffice to flatten the prolapse, and should a permanent ectasy be apprehended, the aqueous humor should be drawn off by making a small curvilinear section with a cataract knife, and after this applying the protective bandage, and the whole procedure repeated until the production of a flat cicatrix has been accomplished. Should this proceeding not attain the desired result, or should iridectomy appear indicated for the purpose of restoring vision by the formation of an artificial pupil, or on account of an established increase of tension (the result of the ectatic corneal cicatrix), the operation of iridectomy should be performed.

Iridectomy should also be resorted to if a corneal fistula has become established, and has refused to close within eight, or, at most, fourteen days, under the protective bandage and instilla-

tions of tincture of opium, perhaps even after careful touching with a finely-pointed stick of nitrate of silver. In this case the operation is difficult, on account of the diminished depth or total absence of the anterior chamber, and also on account of the greater softness of the eyeball ; but it is nevertheless the most reliable means to secure the eyeball against gradual atrophy. Probably, as in accordance with my own experience, a retiring of the iris from the region of the fistula, under the influence of atropine or of eserine, is not to be expected.

§ 24. *Wounds of the Crystalline Lens.*—If we except those solutions of continuity which may result from sudden compression of the eyeball (§ 4 and § 10), every wound of the capsule presupposes the entrance of either a long, puncturing, cutting, or perhaps also lacerating body, or of a relatively small foreign body, such as a grain, splinter of glass, stone or metal, which should be instantly sought for in the chamber, or in or behind the lens.

The aperture of entrance is usually to be sought for in the cornea ; not only after actual cicatrization, but also in relatively recent cases, as it may be only discoverable under careful focal illumination. If the injuring body has passed through the iris also, the resulting gap in that structure may be far distant from the corneal wound, and be very difficult to detect. Should the aperture of entrance lie at

the corneo-scleral margin, or altogether in the sclerotic, it will be readily recognized, before cicatrization takes place, by the red or yellowish discoloration of the episcleral tissue; when after cicatrization, however, it may be difficult or even impossible to discover it.

In recent cases examination of the tension of the eyeball should by no means be neglected. After cicatrization of the wound of entrance, tension may be normal, diminished, or considerably increased.

The place where the capsule has been wounded is betrayed either immediately or within a few hours by an opacity of the lens-substance. This opacity nearest the wound is chiefly due to the contact of the tissue of the lens with the aqueous humor, for which reason it first appears at the capsular opening. It may, however, be also attributed to a mutual dislocation of the elements of the lens, in cases where the opacity follows the line of the entering body, or where it takes place at some distance from the wound, especially in its posterior part and in a considerable area. The view that the contact of the lens with the aqueous humor is alone the cause of the lenticular opacity after wounds, might induce to the opinion that the danger of lenticular opacity bears a constant relation to the size of the capsular opening. The deeper the foreign body has entered the lens, the capsular wound remaining the same,

and the harder the lenticular strata which it has to pass, the more certainly will extensive opacity of the lens result.

Prognosis.—As a rule, wounds of the crystalline body lead to total opacity of the lens, with more or less noticeable shrinkage.

In exceptional cases, a partial stationary opacity remains, on the seat and extent of which the prognosis as to the future functional integrity of the lens depends. Now and then, a portion of such a partial opacity disappears after weeks or months. (Rydel, "Reports on the Ophthalmological Clinic of Vienna," 1867, p. 87.)

With young individuals a more or less complete resorption of the lens takes place not infrequently, and the function of such an eye may be the same as that of a simple aphakial one, if the capsule has withdrawn sufficiently from the pupillary district. Should, however, the anterior capsule remain within the latter, vision may be impeded by its forming slight folds and puckerings in coming into contact with the advancing posterior capsule. In such cases relief is readily afforded by discission made after all inflammatory symptoms have disappeared.

If, however, after union of the capsular wound, a more or less considerable amount of lenticular substance should lie inclosed between the anterior and posterior capsules, within the pupillary district; or if inclosed, calcareous, fatty, or similar

remnants of lenticular fibres have formed an incrustation which is especially united to the capsule, giving the latter a chalky, tendinous, or cartilaginous appearance, the prognosis as to the restoration of a clear pupil is the less favorable the denser the membrane appears to be, and the more it is united to the ciliary processes at its periphery, or to the iris or corneal cicatrix in front. At times, in such cases, after considerable dilatation of the pupil, a spot where this diaphragm is much thinner, perhaps permitting the reflection of red light from the background, can be discovered. Under such circumstances, iridectomy at the corresponding place will produce the desired result much better than discission, dislaceration, or extraction of the callous portion.

In most cases, eyes with wounds of the crystalline body must be considered as endangered, or as altogether lost; not only because of the accompanying injuries of the iris, cornea, and ciliary body, leaving out of present consideration the presence of foreign bodies which have penetrated even behind the lens, but also in themselves, by reason of the pressure which the rapid swelling of the lens, when exposed to the aqueous humor, or by its dislocation, exercises on the cornea, the iris, or the ciliary body. Even if such an eye should not, as it frequently does, be lost by inflammation with fibrinous, plastic, or purulent exudations; or even where, after prolonged suffering of the patient,

the lens has finally become absorbed, the eye may have become amaurotic by pressure (excavation of the optic nerve), or by extensive choroiditis, with atrophy of the retina.

If we constantly bear in mind that the retained lens is more or less flattened by the tension of the anterior capsule, and that consequently a constant mutual pressure exists between the soft cortical substance and the capsule, and that the cortical portion, when exposed to the aqueous humor, swells more or less, and the more rapidly the more extensive the contact between the two, we can understand, that with all capsular wounds which by their size permit of the passage of lens-substance, that such substance will pass forward into the aqueous humor. This gap may be readily enlarged, inasmuch as the aqueous can obtain access to the cortical portion lying behind the capsular gap. From this results the appearance of flaky or opaque masses in front of the capsular opening, whose base and projection (towards the cornea) can be quite accurately judged of by means of focal illumination and examination from the side.

During the absorption of the portion of the lens protruding into, or which has perhaps even fallen to the bottom of, the chamber, the eye is in a state of irritation (increased ciliary injection, lachrymal flow, photophobia), and may easily become attacked with an iritis. If little by little

new portions become pushed out, the equator of the lens will be found to decrease in its diameter, although a complete expulsion and absorption seldom results, the anterior comes into contact with the posterior capsule before all remnants have disappeared, and in conjunction form a more or less plane partition between the vitreous and aqueous humors. This is tensely held in place, by the zonula, between the apices of the ciliary processes, thus inclosing variable quantities of metamorphosed lens-substance, and which in fortunate cases consists in the pupillary district of the posterior capsule alone, the centrally ruptured anterior capsule having become rolled up or contracted towards the periphery.

On the average, from two to three months are requisite for the completion of this, the most favorable termination of injury to the lens, with gaping capsular wound. If the patient is over twenty-five years of age, the nucleus of the lens is already more or less hard and twice that time may be requisite; indeed, resorption may never occur.

The favorable termination just described may become suspended at any time by closure of the capsular wound through the formation of a thin, transparent membrane, which, in some cases at least, is to be considered as a product of the capsule itself, filling up the gap, as it in many cases decidedly does without involving the iris or its exudations.

Most frequently wounds which close in this manner are merely small punctures or short rents. In such a case, either no lens-substance has escaped, or its further extrusion ceases, and we no longer perceive anything protruding into the aqueous humor; the lens decreases somewhat in size, but finally remains stationary as a more or less shrunken cataract. Flap-shaped or long linear wounds are closed in the manner mentioned, or by an opaque connective tissue substance, especially when they lie in contact with the pupillary margin or with a wounded portion of the iris; or if, as a result of keratitis, iritis, or cyclitis, fibrinous exudations cover the capsular wound. Not infrequently such exudations from the ciliary body are deposited in the posterior chamber, and are gradually converted into dense masses which first drive the iris forward, and at a later period produce an intimate union of the shrunken, thickened capsule with the ciliary processes. Such connections are occasionally recognizable after dilating the pupil; but sometimes they are only discovered when the attempt is made to remove the cataract from the pupillary region.

Similar to these are those cases in which a species of cicatricial band is formed between the capsular and corneal cicatrices (usually also with a part of the iris). The cicatricial tissue, thickest near the cornea, spreads fan-shaped over a more or less extensive part of the capsule. If, as is

usually the case, a part of the pupillary margin of the iris is still free, it will not be difficult, after iridectomy, to find a region where the remaining lens substance is still surrounded by normal capsule, and where a discission would hasten absorption.

However favorable larger capsular wounds, particularly those with the formation of flaps, are to the completion of the process of absorption and for the subsequent retraction of the anterior capsule from the pupillary district, they must always be declared dangerous, setting aside for the nonce the injury of the cornea, iris, etc., as they readily lead to swelling of great extent and its injurious results. As soon as any considerable area of the lens is exposed to the immediate contact of the aqueous humor, it simultaneously swells at different and numerous points, thus producing not only pressure as a mechanical injury, to the iris and even the ciliary processes, but also increased pressure on the whole enveloping membranes of the eye as an increase of intraocular pressure, and consequently a disturbance of the circulation. The mechanical injury offered to the iris is easily demonstrated, when a portion of the lens has fallen into the anterior chamber, because corresponding only to the place where this fragment lies between the cornea and iris will ciliary injection make its appearance. In other cases the iris, in part or in whole, is pushed forwards. Regions where the

ciliary body is irritated, are marked by a partial, or if it be general, a partially more intense, ciliary injection, or by an increased sensibility of the part in question. The inflammatory process in the iris or the ciliary body is also manifested by the existence of hypopyon and the obstructive engorgement of the vessels by hyphæmia. In general increase of tension the eyeball becomes either spontaneously painful or painful on pressure; the pains radiating in the direction of the first and second divisions of the trigeminus; copious flow of tears and photophobia accompany this condition. The eyeball feels decidedly hard to the touch, and œdema of the conjunctiva of the ball, and even of the lids, is indicative of extreme danger of the eye through severe inflammation of the uveal tunic, or by compression of the retina or the optic nerve.

Injuries of the above description are better borne in childhood and even in adolescence, than in the adult or senile eye. Certainly a soft lens is better fitted for rapid absorption than one of which the nucleus alone or more of its substance is hard; but on the one hand the rate of waste and repair, and consequently also of absorption, is much more active in childhood, and on the other a lesser resistance on the part of the ocular capsule, more particularly the sclerotic, must be claimed as an explanation of the fact mentioned. Without doubt, this peculiarity must be taken into

consideration in the judgment of a relevant case and of its results.

Treatment.—As soon as the existence of a capsular wound has been determined, and as long as its reclosure can not be assumed, the task for therapeutics, as far as the crystalline body is concerned, lies in the prevention, as far as possible, of posterior synechia, and the endeavor to tear such synechia, if already existing, by the energetic use of atropine. Further, to avoid or to ameliorate as much as possible the results of irritation of the iris and the ciliary body, and the increase of intraocular pressure, by the use of anodynes and a suitable antiphlogistic treatment.

Where intense swelling is imminent or has already taken place, where iritis or cyclitis, as the result either of the swelling or of the coincident dislocation of the lens, or provoked by coexisting wounds of the iris or ciliary body, are threatening or have already set in, strict and even preventive antiphlogosis is the chief indication. Under certain circumstances the performance of venesection will be justifiable in healthy adults, while in other subjects local abstraction of blood at the temples or the mastoid region will suffice. Extreme swelling of the lens with its results can be held in check by nothing so well as by the continuous application of ice-cold compresses (best, small icebags), as I have had frequent occasion to witness. With this, subcutaneous injections of

morphia in cases of severe pain, and the use of chloral-hydrate in insomnia should not be omitted.

At times the dangers and accidents of the tumefaction can be considerably diminished by a slow exhaustion of the aqueous humor. After correct fixation of the head, the eyeball, and the lids, under anæsthesia if necessary, a long section is made along the corneal margin at a spot where we may safely expect that by slowly withdrawing the blade nothing but aqueous humor will follow, and that no fragments of the lens will become impacted in the wound. The knife to be employed is a geniculate curved lance-shaped one; and in making the section it should never be turned on its axis, or any pressure be exercised on the eyeball. The valve-like opening thus formed, and which can be readily reopened with a scoop, not only temporarily relieves the eye from pressure, but decidedly accelerates the resorption of the lens. It may be here remarked, also, that we can profit by this method (which Wernek of Salzburg seems to have been the first to recommend) in those cases where it appears desirable to re-establish the absorptive process of the lens, when checked by closure of the capsular wound. After the draining away of the aqueous humor the delicate membrane closing the capsular wound is lacerated, since the vitreous humor presses forwards all the tissue which lies in front of it.

The removal of the lens, through a similar

though more extensive corneal opening, is to be considered more as a doubtful remedy, as we seldom succeed in removing the lens as a whole, or even its greater part, and thus do not obviate the dangers of mechanical irritation, or of increased pressure; perhaps, indeed, we even increase them. It is only when a hard nucleus is impacted in the pupil, or when a lens prolapsed into the anterior chamber begins to incite serious trouble, that this remedy becomes better than none.

If the pupillary margin is not only agglutinated to the capsule at some circumscribed locality, but also its whole circumference; or if the tension or dragging of an agglutinated portion allows us to conclude that, to this alone are the continued symptoms of irritation and inflammation due, it will be best to perform an extensive iridectomy. Even here, it is as a general thing advisable not to endeavor an exhaustion of the lens, since a complete removal is as rarely feasible here as in the simple puncture. Where no immediate danger is imminent, provided the iris is very vascular and softened, we should, if possible, wait until this condition improves, as we risk securing very little of the fragile iris, but rather an extensive hemorrhage into the anterior chamber.

Eyes in which, after a capsular injury, the lens is becoming wholly or partially absorbed, even when no synechia exists, are in an irritable condition until the capsular sac is completely closed,

be it by the production of a membrane closing the gap, or by an agglutination of both capsules. Until this is accomplished, they must remain under surgical supervision, their amount of light received being tempered by protective glasses, and accommodative exertions of the other eye being avoided. Sometimes the closure is only an apparent one, as a very slight circumstance—for instance, a pressure on the eye—suffices to rupture it, and cause the extrusion of lenticular substance with its sequelæ. If, however, synechia or atresia of the pupil have taken place, such an eye remains liable to the dangers of chronic iritis and cyclitis, until an adequate iridectomy has been performed.

Concerning the encheireses, employed against the various forms of traumatic cataract itself, I must refer to the text-books on operative technicalities. For the non-specialist, who does not feel called upon to operate, it suffices to be able to decide the question whether a more or less useful degree of vision can be regained by any operation. For this purpose it is pre-eminently essential, where no qualitative perception exists, that the light of a candle-flame be appreciated at a distance of from fifteen to twenty feet, and that from various parts of the periphery there be ability to project this flame correctly, that is, to assign it to its proper place in space, and not merely an ability to state that it is light or dark in front of the eye in question.

(B.) *With the Foreign body remaining behind.*

§ 25. *General Remarks.*—The question whether we have to deal with a foreign body in, behind, or on one side of the eye, is at times very easily answered, at others only after the most thorough and painstaking investigation and due consideration of the history of the case; sometimes a decided opinion is not possible until after prolonged observation. The same remark applies when the foreign body is neither visible nor palpable, until the discovery of its seat and physical properties, points which decisively influence the prognosis and treatment. The referring of a functional disturbance or an inflammation to a foreign body is occasionally rendered difficult by the fact that a small foreign body has at the time of its entrance, and even for some considerable time after, caused no alarming symptoms. In the case of the orbital cavity this holds true for foreign bodies of a considerable size. Besides this, we should not forget that in the production of a wound by an instrument which has unquestionably been removed, a foreign body, such as a cilia, may have been driven in or left behind by being caught or broken off; as also, that with a visible foreign body, another invisible one may coexist.

Whenever a suspicion is held that a foreign body has penetrated to the interior of the eyeball,

the tension of the latter should be examined (as a diminution of such tension points as a rule to perforation of the ocular wall), and in recent as well as older cases (after closure of the wound), the whole visible surface should be investigated, particularly with focal illumination in order to discover the fresh or cicatrized aperture of entrance. It will rarely have to be sought for in the skin of the lids or the vicinity, and here also the wound will be found beyond the fornix conjunctivæ only in exceptional cases. Certain cicatrices of the sclerotic, resulting from the entrance of very small foreign bodies, are sometimes impossible to find. If the wound or cicatrix is found within the area of the cornea or the scleral border, we should examine, both by focal illumination and the ophthalmoscope, whether a rent or a puncture of the iris is present, which may, however, be obscured by blood. Opacity of the lens without any demonstrable opening or cicatrix of the capsule, the pupil being well dilated, may be also due to simple concussion. At the same time capsular wounds, in themselves, as well as their sequelæ do not justify any conclusion as to the entering and remaining behind of a foreign body in or beyond the lens.

As to the situation of a foreign body in the external tunics, inspection, or perhaps palpation with the fingers or a sound, will usually enable us to decide. When in the transparent media, its presence can be detected, even after opacities have

appeared, by means of focal illumination of the dull area, even after its recognition with the ophthalmoscope is no longer possible. Opacity near the region of a wound, without the shining through of a foreign body, of course permits of no positive decision as to its presence. Where both means of investigation fail, the discovery of a spot on the anterior segment of the sclera, which is marked by excessive reddening, or by increased sensibility to palpation (with a silver probe), will sometimes reveal the vicinity of a foreign body. The introduction of a sound into the interior of the eye for diagnostic purposes is harmless, only when the greatest precautions are employed.

The statements of the patient are, as regards the locality, not always of value, for the foreign body may lie at a place quite distant from the spot where, judging by the entrance wound and the patient's assertions, we might expect to find it, either by gravitation or by deviation from its original direction, be it due to changes of the ocular position at the moment of the injury, or to obstructions which it encountered in its passage. It can also have been thrown back from the wall opposite the aperture by which it entered towards the latter and settled downwards in its backward passage.

Dr. Berlin ("Arch. für Ophth.," xiii., 275) justly calls attention to the *discrepancy between the visible symptoms of injury and the intensity, duration, and refractory character of the internal inflammatory pro-*

cesses, as of considerable weight for the determination of a foreign body in the eye.

The physical properties of the perforating substance, especially with regard to size and shape, can seldom be accurately determined, except in case of shot or powder grains, unless it lies before us; for instance, in the cornea, the anterior chamber, the lens, or the vitreous humor, provided this latter be still transparent. Its size can be only approximately judged of from the size of the wound, even when the latter is yet open, as it may have entered (unless cubical or spherical) with its lesser diameter; and where the propulsive power has been great, the wound usually turns out to be a relatively smaller one. It is especially percussion caps which provoke an incorrect judgment as to size and shape; half or even whole caps have been found where only a small fragment had been suspected.

After deciding as to the presence, the locality, and the physical properties of the foreign body, as far as the two latter points can be settled, the question arises whether it is admissible to leave it *in situ* or whether it should be removed; further, whether the manipulations necessary for such removal promises a certain success or whether they might be fruitless, and expose the eye to a greater danger than it is subjected to by the body's remaining behind unmolested; finally, whether, with reference to the uncertainty of removal and

the sequelæ (with or without such interference), it is not more advisable to enucleate immediately or after pursuing the expectant plan.

In doubtful fresh cases it is well to wait a few days, employing strict antiphlogosis, and carefully watching the eye to see whether clearer indications for prognosis and operative interference arise.

Nevertheless, the general rules that foreign bodies should be rather removed early than late, and that in clear cases, where large or irritating foreign bodies are present, we should never wait for severe reaction, are not to be lost sight of.

The difficulty of deciding lies in this, that on the one hand the patient cannot be readily brought to consent to severe operative manipulation, especially to enucleation, while on the other, experience teaches that many foreign bodies are borne for a long time in certain tissues without causing reaction, and that in other cases, however, the same result is provided for by permanent or temporary incapsulation, while in a more extensive series of cases (not to say the rule) an insidious or acute inflammation conducts to the destruction of the affected, and perhaps even to sympathetic affection of the other eye.

As this diversity of results not only depends on the character of the body but also on its seat, we will classify these injuries according to the latter point, but at the same time considering, as far as possible, the character of the foreign substance,

while the accompanying wounds we presume the reader is by this time acquainted with.

The foreign body is, leaving out of consideration the appendages, so-called, of the eye, situated either in the tunics (conjunctiva, cornea, sclerotic)—and is then readily removed—or, after producing a perforating wound, is lodged in the anterior segment (chamber, iris, ciliary body, lens), or in the posterior (vitreous humor, retina, and choroid). Behind, or to either side of the eyeball, foreign bodies may have penetrated, after double perforation of the bulb, or from the fornix of the conjunctiva, or after perforating the lids, or finally, the bony walls of the orbit.

§ 26. *Foreign Bodies enter the Conjunctiva* usually as the result of accident; for instance, by a violent current of air, or through the carelessness of the individual himself; occasionally, however, as the result of criminal acts.

The results may be immediately so severe as to direct suspicion to the presence of a foreign body, they may also be slight and remain unnoticed until the occurrence of inflammation leads to discovery of the cause. Cases also occur, especially in children, where both the immediate symptoms of irritation as well as the later inflammatory disturbance is not attributed to the injury, but to any other cause. It is also possible that we have to deal with an irritation or inflammation, inten-

tionally excited by the introduction of foreign substances. (See Part IV.)

Small foreign bodies can readily escape detection by their transparency, they may be covered with mucus, or concealed by wound-granulations, or by considerable swelling of the conjunctiva or the caruncle. Larger, especially long bodies may have penetrated more deeply into the subconjunctival tissues and project partially into the conjunctival sac, especially when occurring in the fornix, at the caruncle, or perhaps they may be discernible only on probing.

Here, as in all other cases, a careful examination with the naked eye, by means of focal illumination, a simple magnifying glass, or with the probe, in different positions of the eyeball, after eversion of the lids, etc., is essential. At times it may be necessary, for the purposes of examination, to resort to anæsthesia, as in violent blepharospasm. We should also satisfy ourselves whether the existing symptoms are due to the presence of the foreign body or its remnants, and further whether a foreign body, which we concluded to seek for on the surface of the eyeball, has not penetrated deeper, and has to be sought for in, by the side of, or behind the globe.

Prognosis and Treatment.—The prognosis as a rule is favorable, if the cornea has not been drawn into sympathy by a prolonged sojourn of the foreign body. The removal will hardly tax the physician.

Only small grains, as gunpowder, or splinters in localities where the conjunctiva is very loosely attached, can usually neither be scraped nor scooped out, but must be seized together with a little conjunctiva and snipped off. In the same way the paring off of proliferating granulations is to be preferred to their cauterization.

§ 27. The presence of a *foreign body in the cornea* can be determined with certainty, either with the naked eye, the lens, the reflex image, and focal illumination. Light-colored bodies will be more readily visible when the direction of the visual line is such as to place the pupil behind it; dark-colored ones, on the other hand, more easily when before a light-colored iris. It is only when inflammatory reaction has made its appearance that it may be difficult to decide whether the opaque region contains a foreign body. More difficult, but still perhaps always possible with oblique illumination, is the determination of the direction and the depth to which the foreign body has penetrated. As to the nature of the foreign body the examination will yield more reliable information than the statements of the patient. If, at times, the brownish black cover of the wing of an insect, or half a seed husk has been diagnosticated as a "prolapsus iridis," or *vice versa*, a prolapsus has been mistaken for a foreign body attached to the cornea,

the examination must have been a very imperfect one.

Prognosis and Treatment.—It is only gunpowder (charcoal) and sometimes small calcareous particles or minute flakes of copper that can remain in the cornea (or even in the lens) without causing suppuration. In all other cases removal is pre-eminently indicated, for we do not know how far the suppuration of the cornea will extend. This process, which in the most favorable case terminates in the expulsion of the body with a more or less extensive and intense opacity remaining behind, may also lead to corneal perforation with its results, and consecutive inflammation of the iris; perhaps, also, of the ciliary body, and to purulent accumulations in the anterior or posterior chambers, or even in the vitreous humor (purulent cyclitis, panophthalmitis).

In children, and even with grown persons, anæsthesia may be necessary, in order to remove the foreign body, for the operation is very painful, and sometimes unexpected movements on the patient's part render its performance impossible, especially when the foreign body is deeply seated. Such eyes are, on the average, very sensitive to light, especially if they have already been meddled with, or, when considerable ciliary injection, or even iritis, has supervened. It is well, therefore, to close the other eye and to place our patient so that the light can only fall laterally and from but

one window or flame, taking due care that the reflex (light image) does not interfere with the operator. The head, as well as the lids, is to be fixed by an assistant. In default of the latter, intelligent patients can be placed in a high-backed chair, while the operator's free hand is employed to press the head back against the cushion, perhaps, also, in fixing the upper lid with the thumb. The holding of the head could be also intrusted to a layman, the fixation of the lids accomplished by appropriate appliances, and the steadying of the globe by fixation-forceps. If the fixation of the upper lid is done by means of the thumb of one hand, the upward motion of the cornea can often be avoided by pushing the lower lid down and backwards with the ring-finger of the operating hand, the instrument being held by the thumb, index- and middle fingers of the latter. Some find it more convenient to stand behind the patient, who is placed on a low stool, and press his head against the pit of the stomach. In this case, the fixation of the lids and the prevention of the upward escape of the cornea can usually be effected with the other hand. The removal of foreign bodies under focal illumination is to be recommended when the latter, by reason of their small size or transparency, are scarcely visible in daylight.

If the *foreign body* should be merely a *small* splinter of metal or stone, a straight lance-shaped

cataract needle would be the best instrument adapted to pick it out and subsequently scrape away any remaining deposit on the wound. Some employ a grooved gouge or needle. If a compact body is deeply imbedded, we must at first endeavor to get under or behind it, and for this purpose make an appropriate section with a cataract knife. Small particles of the foreign body or its coating, when left behind, are as a rule injurious, for the irritation and inflammation depend rather on the character than on the size of the penetrating body.

After complete removal, the symptoms (pain, photophobia, pericorneal injection) recede, and the injured person frequently needs no further treatment. If, however, he has presented himself after several days have elapsed since the accident took place, or if the body has penetrated more deeply, we either find iritis already established or incipient (discoloration of the iris, narrowness of the pupil); in this event, atropine and a surveillance of the eye for one or two days are essential. With more extensive losses of substance, or with already established corneal ulcerations, the corresponding treatment for these affections is to be employed (atropine, protective bandage).

If the foreign body is larger, and long or flat (metal, stone, wood, etc.), and if, besides, we have found, through focal illumination, how deep it

has passed into the cornea, and, further, whether it has penetrated to the chamber, or if a part of it lies outside of the cornea, these particulars, and the character of the body, decide the proceedings which we should adopt. As a rule in such cases anæsthesia is indicated, and one skilled assistant at least is necessary.

If the body has penetrated obliquely in a manner similar, for instance, to a splinter run under a finger-nail, and if it is not to be expected that (provided it is still partially without the cornea) it can be seized with strongly-toothed forceps and extracted; in order to be able to grasp it securely, the layer of corneal substance covering it should be divided with a cataract or lance-shaped knife in front or to one side of it.

In cases of long or flat *vertically impacted bodies*, which either do not protrude or protrude so far that the attempt to grasp them can only be made at the risk of pushing them in still further, I have, through a laterally established corneal opening, introduced the scoop behind the body, and thus pushed it forwards, or at least supported it in such a manner that I could safely grasp it. Desmarres has introduced his paracentesis needle into the chamber, and employed it as a solid support for the foreign object, in order to facilitate its extraction or lifting out.

It is possible that where a *foreign body extending into the chamber* can obviously not be removed

through the aperture of entrance, we may be forced to enter the chamber, with the forceps, through an incision at some better locality, in which case it must be allowed the iris and capsule are easily injured. In withdrawing the knife, rapid draining of the aqueous humor is to be avoided as far as possible; consequently no pressure should be exercised on the eye, nor should the knife be turned on the axis of entrance.

§ 28. *Foreign Bodies within the Anterior Chamber, or in and behind the Iris*, have usually entered through the cornea, and rarely through the sclerotic. In fresh cases it is not difficult to find the entrance wound, except when we have considerable hæmophthalmus, when the globe will feel soft. Grains of shot, or fragments of percussion caps, can reach the chamber from behind, generally after perforating the upper lid, the sclera, and the lens, or passing by the side of the latter. Besides this, it is possible for the foreign body to be attached to the cornea for some time, and then either spontaneously (with rubbing of the lids), or after unsuccessful attempts at extraction, to fall into the chamber.

The foreign body may, by reason of its small size or peripheral position (usually by sinking downwards), be hidden behind the sclerotic border. Circumscribed reddening, and sensibility to palpation, at the corresponding part of the

sclera, as well as detraction of the pupillary margin, may point to its situation; focal illumination will settle the question, provided hemorrhage, fragments of lens-substance, or corneal opacities do not prevent it. In the iris, dark spots of pigment, which occur in advanced life without having any pathological signification, may, perhaps, be confounded with powder-grains or splinters of iron. In many cases the presence of a foreign body manifests itself in the anterior chamber by an *intensely yellow, or whitish-yellow, mass*, which forms its capsule, or by a point of the foreign body projecting through the iris into the anterior chamber, where it can be recognized by lateral illumination.

The bodies most frequently encountered in the chamber and iris were pieces or splinters of metal (fragments of percussion caps, of steel, iron, or shot), of stone, porcelain, glass, more rarely wood, bristles, and, exceptionally, cilia.

Prognosis.—In some cases, foreign substances have remained in the chamber *without reaction* having taken place, especially cilia, but also fragments of small, or even considerable size, of the substances just enumerated. Thus Pagenstecher found a cilium which had been borne for ten years without any irritation, and Professor Jaeger ("Cataract and Cataract Operations," Vienna, 1854, p. 68) found a bright shining piece of gun-cap, one line square, which was slightly adherent to the iris,

and had lain in the chamber for five years, and, even after an accidental commotion of the eye, had produced no inflammation. In a case observed by Jacobs, of Dublin, a fragment of stone had produced serious irritation only at the end of a sojourn of four years in the anterior chamber.

A few trustworthy observations (by Lawrence, Wardrop, Cooper) speak for the possibility of a disappearance from the anterior chamber through oxidation and absorption of small pieces of steel or iron, such as broken-off cataract-needles or knife-points.

In other cases temporary or permanent *incapsulation* took place, at times with considerable inflammatory exacerbations. With such, the eye may maintain its form, and even its functions, more or less perfectly; usually, however, it is more or less severely injured by the extension of the irritation to the iris or to the ciliary body. Sometimes it becomes atrophic, and not unfrequently the other eye is threatened with destruction through iridocyclitis.

In most cases severe *inflammation* with suppuration immediately follows or takes place after temporary encapsulation. If the cornea becomes involved in the process of inflammation and dissolution, and particularly if this occurs partially, the foreign body may become expelled and the eye so far preserved that its function may be re-established, with or without an auxiliary operation

(iridectomy, cataract operation); as a rule, however, the inevitable result is a loss both of shape and function. If, after the appearance of intense reaction, the cornea is not perforated early, the well-known phenomena of suppurative keratitis, or of iritis and cyclitis with suppuration, and their further sad results, among which panophthalmitis with final *elimination of the foreign body*, may be considered as relatively favorable, as in this event the other eye is seldom endangered.

Treatment.—As a rule we cannot count on the toleration of a foreign body in the chamber or iris, nor on its permanent incapsulation. The favorable composition or quality of the penetrating object, as well as a slight wound, and especially the absence of symptoms of irritation in spite of the lapse of some time, permit of further temporizing, but with constant supervision. Fresh hæmophthalmus or considerable chemosis, if this latter is rather attributable to the wound than to the irritation by the foreign body, renders a delay of the attempts at extraction desirable, perhaps makes it a necessity, while strict antiphlogosis is kept up. With an iritis or iridocyclitis it will be advisable to subdue the symptoms with blood-letting, cold applications—to be replaced later by moist heat—cathartics and narcotics. If, however, no noticeable remission has resulted within a short period, the operation can no longer be delayed. If certain appearances of the wound and

the vicinity point to the probable expulsion of the foreign body, temporization, under the use of moist heat, is perfectly justifiable. In case of profuse suppuration, free incision of the abscess in the vicinity of the foreign body, may materially shorten the process.

The operation itself will, in some cases, have for its object simply the removal of the foreign body, which, it is true, can not be effected without the incision of the iris at the same time; in other cases, especially with already established atresia of the pupil, we will be tempted or even forced to perform an appropriate coremorphosis, and with either pre-existing injury of the lens, or such unavoidably made during the attempts at extraction, we will have to decide beforehand whether we will be compelled to combine extraction of the lens with that of the foreign body.

For the purposes of removal, or rather for the introduction of the forceps, the size of which is to be determined by the size of the foreign body or the coexisting adhesions, a still existing or only slightly closed wound may be selected, which latter may be reopened with the probe or a cataract knife, and extended with the scissors according to the exigencies of the case. This in itself harmless procedure can frequently not be employed by reason of the unfavorable position of the wound, with regard to the foreign body, or because of the necessity of a coincident iridectomy

or extraction of the lens. Usually the chamber must be newly opened with a lance-shaped or cataract knife, which is difficult although not impossible in the case of a shallow or obliterated chamber, but which perhaps may demand serious consideration and considerable dexterity because of the size and shape of the foreign body. When we are uncertain as to the size of the foreign body we naturally prefer to make a long wound, but at the same time prepare to have the wound further opened with the knife or scissors if the object when pulled upon is checked there. This procedure is to be done by an assistant previously instructed for this emergency. A large wound, even if not straight, is better than one which is contused or lacerated.

In general, peripheral sections lying in the scleral border are preferable, especially when, by this method, the knife can be passed wholly or partly behind the foreign body. We should not forget, however, that with such wounds, if they are longer than one-quarter of the corneal circumference, prolapse of the iris readily takes place, and excision of the iris for this reason becomes necessary. In other cases a wound made in the central region of the cornea is more advantageous or alone applicable to insure access for a secure grasping of and traction upon the foreign object. The locality, direction, and size of the cut must be so adapted that, after having reached with the

forceps a spot where a secure hold can be effected, the instrument can be sufficiently opened and advanced without displacing the foreign body, and also where care is requisite with regard to the iris and especially the capsule, that the drawing of the body into the wound may be accomplished without much twisting or turning.

If the capsule is opened, and we determine by oblique illumination that a more or less hard nucleus is present, as is generally the case after the thirtieth year, the wound should be made with reference to a possible extraction, or it should be subsequently extended. With young individuals we may remain content, after removing the object, with the performance of iridectomy, perhaps leaving the lens to absorption, or performing simple linear extraction subsequently, with or without excision of the iris. Care must be taken that no remnants of the lens or parts of the iris become impacted in the wound.

From what has been said it naturally follows that extraction of a foreign body from the chamber or the iris, should as a rule not be attempted without anæsthesia, and certainly never without competent assistants.

§ 29. *Foreign Bodies in the Lens* (or close behind it in the vitreous humor) have usually entered by way of the cornea, rarely through the sclera. An accurate examination of the entrance wound, aided

by certain points in the history of the case, yields valuable information as to the size of the foreign body. Occasionally the entrance of the latter has taken place with such slight symptoms that only the visual disturbance following called attention to the serious nature of the injury. The foreign body may, through the opacity of the lens, become in a few hours hidden from the eye of the examiner. It is rarely possible to recognize the situation of the body in the lens, through careful inspection, under focal illumination, in consequence of diffuse opacification. A gap in the iris, or an indentation of the pupillary margin, as well as a demonstrable gap or cicatrix of the anterior capsule, point to the entrance of a foreign body into the lens, but they do not prove its existence in the latter.

Prognosis.—In isolated cases, after the entrance of very small metallic splinters through a more or less peripheral portion of the lens, a part of the resulting opacity has been known to disappear; and there are even a few cases on record where a partial clearing up (even to the normal perfection) has taken place in spite of the continued sojourn of the foreign body within the capsule. (“Bericht über die Wiener Augenklinik,” Wien, 1867, pp. 87 and 95.) In addition to the fact that in those cases the injuring body had not passed through the nucleus of the lens, I would remark that the cases of fortunate termination were those of young

individuals. (In one case, however, furnished by Desmarres, the age is not mentioned.)

As a rule, we must be prepared for a total and permanent opacity. Subsequent changes usually depend upon the condition of the capsular wound. (Compare § 24.) Iron splinters may give the opaque lens an ochreous yellow color, and this color in such cases is most intense near the object. Berlin ("Arch. für Ophth.," XIII. b. 275) observed the dark tinge of the traumatic cataract in two cases, when the iron splinters lay in the vitreous humor, and I saw in a boy where a piece of copper (percussion cap) had penetrated the lens two years before, where the lens exhibited a dark opacity, passing to a reddish hue, without being diminished in size, nor did the eye manifest any symptoms of irritation or of inflammation. One great danger of foreign bodies in the lens is, omitting for the present the increase of pressure arising from a too rapid swelling of the lens (secondary glaucoma), the possibility of their being pressed into the anterior chamber, there irritating the iris and ciliary body.

Treatment.—The removal of an object impacted in the lens is the constant indication, and, as a rule, can only be accomplished together with extraction of the lens. Where the capsule is yet open, no procrastination is permissible. It may happen that it is advisable to perform iridectomy, especially when we apprehend the retention of the

body behind the iris, or if the body appears covered by a considerable stratum of lens-substance. In other instances it may appear appropriate to hasten the absorption of the lens by a discission, before proceeding to extract.

The following is a case published by Von Graefe in his Archives, Vol. II., B., a. 226. "A piece of metal entered the right eye of a laborer, causing slight irritability and defect of vision. Ten days later a high degree of cataractous opacity was observed, and a delicate cicatrix was noticeable opposite the lower and inner part of the pupillary margin; it was scarcely half a line long, and of an immeasurably small breadth. As such small bodies produce cataract through contusion of the eye, this alone led to the suspicion that the metallic filing had penetrated to the interior of the eye. When, for the sake of a more accurate diagnosis, the pupil was dilated and the anterior capsule examined with oblique illumination, a solution of continuity was found in the latter, about one line in length and half a line in breadth, through which some loose portions of the lens were protruding into the aqueous humor. This capsular wound was not opposite the corneal cicatrix, but near the centre of the pupil. If both wounds were produced by the entrance of the same body, this latter must have passed from below and inwards to above and outwards, and, in accordance with this supposition, attention was chiefly directed to

the external and upper part of the lens. The opacity was still translucent enough to permit of an insight as far as the posterior cortical portions. The foreign body, a *small metallic splinter* of about two-thirds of a line in length, was discovered in the posterior cortical substance, just about opposite the external margin of the dilated pupil. The questions at issue were: first, the removal of the cataract; second, the extraction of the foreign body.

“The latter indication seems to me a decidedly justifiable one, for we can never count on the good fortune that foreign bodies, having entered the eye, become harmless through incapsulation; on the contrary, the usual occurrence is that chronic inflammations of the inner membranes, either continuously or intermittingly, lead to loss of vision. I will admit that foreign bodies in the lens or iris prove exceptions to this rule more frequently than those seated in deeper structures, still, in consideration of all facts, it will always remain a correct principle to remove the foreign body from the eye, wherever accessible, as soon as it produces the slightest condition of internal irritation.

“The simplest solution of the two problems would have been afforded by the extraction of the lens; however, the cataract was too immature not to cause apprehension of serious dangers both from the linear as well as from the flap-extraction; besides it was doubtful whether, with such extrac-

tion, the small foreign body might not be rubbed off at the pupillary margin, or on the posterior surface of the iris, and then in this case provoke a bad termination. I consequently resolved on a different plan of treatment. The capsular wound, being too small for a rapid absorption of the lens substance, was to be enlarged somewhat by a cataract needle, and the imbibition of the parts in the vicinity of the foreign body accelerated as much as possible by directing the needle in the direction of the latter; the foreign body would necessarily have to sink as absorption progressed, and I hoped that consequent on its approach to the capsular wound, or its escape from the latter into the aqueous humor, it would become more accessible for its secure removal.

“This, in fact, took place; the dissolution of the anterior part of the lens increased more and more; and more flocculi of the lens were continually set free into the aqueous humor. About two weeks after the operation the foreign body was already located opposite the upper margin of the capsular wound, and no longer in the posterior but in the middle part of the lens. One week later it passed into the anterior chamber, surrounded by saturated lenticular masses. I now believed that I should not delay its removal, for it was to be expected that the metallic fragment would sink in the chamber, and as usual settle in the angle between the iris and cornea. How difficult, how-

ever, the removal of a foreign body from this place is, every practical ophthalmologist will know who has ever attempted this laborious task; it is almost impossible to remove very small metallic splinters attached to the iris without at the same time catching the iris when it is closely applied against the cornea after the aqueous humor is drained off. Therefore advantage was taken of the suspended position of the foreign body to introduce the lance-shaped knife under the expanded cortical substance inclosing the foreign object, and after simply withdrawing the knife the former together with the latter escaped. The extraction of the remaining lens-substance was performed after the familiar method of simple linear extraction."

I considered it expedient to communicate the above remarks of Graefe verbally, as they eminently illustrate the principle that, as in all other operations generally, but more particularly in removing foreign bodies, we cannot follow any fixed set of rules without thorough reflection, but that the plan indicated in any special case must be modified according to existing circumstances, in accordance with the generalization derived from experience. We must construct a plan of operation in every special case, weigh the chances of success or of failure, and at the same time recollect the possibility that during the progress of the operation itself one or the other deviation from

the original plan may become necessary. We must know, at least approximately, what can be accomplished, and how far we may go.

If, by means of focal illumination or through the ophthalmoscope, the presence of a *foreign body in the vitreous humor behind the lens* could be determined, which will be possible perhaps only in recent cases, it might be advisable to undertake the extraction of the lens (by means of the curvilinear section), before the foreign body shall have become removed from the pupillary region and patellar fossa or before it has excited decided symptoms of inflammation. ("Graefe's Archiv," IX. b. 82.)

Before doing this, we should weigh the question whether, after removing the lens and dividing the posterior capsule, we have any chance of removing the foreign body. If the answer to this question be affirmative, we need not fear a moderate loss of vitreous humor. This latter is not by far so serious as the inflammation provoked by a foreign body when it has approached the uvea. (Compare § 30.) It is the curved section alone which yields a wound of such a nature as to permit the necessary introduction of the forceps without much tension. As a rule we will also have to make a considerable iridectomy or precede the extraction by such, partly in order to facilitate the complete removal of the lens, partly in order to be better able to see and seize the foreign object.

Even if the eye should perish after the extraction, if the foreign body is only removed, the injured patient is always better off than if the latter had produced inflammation. Should the cornea suppurate while the body lies near the patellar fossa, its expulsion is very probable. (Compare Barton's procedure in the next paragraph.)

§ 30. *In the Posterior Part of the Eye (Vitreous Humor, Retina, and Choroid).* If we leave out of consideration deeply penetrating larger fragments of wood, iron, tin, glass, etc., which are more or less connected with the entrance wound, and project from it, we have here to deal usually with grains of shot, fragments of percussion caps, and with small pieces of metal, glass, or stone.¹

¹ I recently had occasion to observe a pertinent case in which, neither the patient knew of, nor had his physician recognized, the existence of a large foreign body within the eye. A. Marinall, aged 30, a locomotive boiler-maker was engaged, together with a fellow-workman, in riveting a boiler, the two striking alternate blows, the former with a *new* small steel hammer, the latter with a large and heavy one. On "missing time" the heavy hammer descended upon the small one, which rebounding struck M. in the left eye, knocking him senseless. He was at once taken to a special hospital, where he was examined by the staff and retained under treatment for ten days. He then went to his work for a fortnight, after which he entered another hospital, where he remained under the care of a leading oculist for three weeks. At the end of this time he was again discharged, and once more returned to his work. During his stay in both hospitals, as well as in the

The *aperture of entrance* can in the case of shot, perhaps also in case of percussion caps, lie behind

intervening time, he suffered extreme pain, requiring toward the last the use of narcotics. He came to the Howard Hospital three days after his last discharge, presenting the following appearances: left eye, conjunctiva reddened and injected, circumcorneal injection intense, cornea dull and opalescent, pupil partially and irregularly dilated. The lens was found remarkably clear, and a gray reflex immediately behind it prevented the fundus from being seen. Neither quantitative nor qualitative perception of light existed, nevertheless photophobia was present; under the stimulus of light, the pupil contracted sluggishly, and to palpation the globe felt very hard. Right eye: marked circumcorneal injection, cornea dull, iris reacted slowly, accommodation greatly impaired, and all light caused pain and lachrymation. On account of the above mentioned unmistakable symptoms the diagnosis of a foreign body was made, at the mention of which *the patient laughed*. I recommended and at once performed enucleation. On making a section of the removed organ in the vertical meridian, the knife was felt to grate upon some hard substance, which, on further examination proved to be a fragment of steel, imbedded in a circumscribed abscess, involving the upper portion of the ciliary body (apparently a dissolving incapsulation, § 28). The vitreous humor was found converted into a shrunken mass, to which the retina was adherent, having separated from its choroidal attachments. Although the most careful scrutiny had not revealed any traces of an opening through which the foreign body could have entered, a cicatricial thickening of the lower part of the sclerotic, between the equator and the limbus corresponding to the size of the foreign body, was made manifest by the section. The foreign body accordingly must have entered from below. On removing the fragment, which was flat and angular, measuring a little more than 1 mm. in thickness, 6 mm. in length, and 4

the conjunctival *cul-de-sac* in the sclera, besides it is sometimes to be found in the cornea or conjunctiva, either readily or with difficulty, depending on its size.

Those injured may not have noticed anything at the moment of the injury, or they may have had their attention called to it by *pain*, *photopsia*, and somewhat later by *hemorrhage* or *visual disturbance*. The visual disturbance, which is seldom altogether absent in the beginning, may be due to direct injury of the retina at the entrance wound, or just opposite, but it is usually dependent on the extravasation of blood into or on the presence of the foreign body itself in the vitreous humor, and is described frequently in the latter case as a *macula*, cloud, or mist, caused by the shadow on the retina, and therefore occasionally appreciable entoptically. The later appearing *limitation of the visual field* discovered on accurate testing, may be the direct result of the injury to the corresponding part of the retina, but may also ensue in consequence of *inflammation of the injured portions of the retina and choroid*, or through *retinal detachment* caused by sub-retinal extravasation through

mm. in breadth, was shown to the patient and recognized by him as a portion of the bevelled edge of his steel hammer. He remarked that the edges of such new implements frequently chipped off. In spite of the beginning sympathetic affection of the right eye, all symptoms of irritation at once subsided, and the patient made a rapid and perfect recovery.—TRANS.

stretching of the retina, by cicatricial traction toward the wound of entrance, or opposite the latter, or by *shrinkage of the connective tissue substance surrounding the foreign body*. (Compare O. Becker, "Bericht von der Wiener Augenklink," 1868, and Berlin, "Arch. f. Ophthalmol.," XIII. b. 275.)

If the transparency of the media should permit, the presence of the foreign body in the vitreous humor, or at its periphery, may be ascertained by the *ophthalmoscope*, that is, if it is not situated near to or on the ora serrata. *If cord or thread-like opacities* pass obliquely or straight through the *lens* from before backwards, in a case where the penetration of a merely puncturing instrument can be excluded, and only a small foreign body is likely to have entered, the presence of the latter in or behind the lens is no longer to be doubted. Occasionally it can be concluded from the presence of a corneal wound (or its cicatrix), and a gap in the iris, with their relative positions, that a foreign body has penetrated by the side of the lenticular equator. In other cases the path taken by the object through the vitreous body can be recognized as an *opaque streak*. (Graefe, "A. f. O.," III. b. 341.) Where the pupil can be considerably dilated, *focal illumination* will not infrequently furnish information as to its seat when in the vicinity of the ciliary body. The *vitreous humor* immediately surrounding the foreign object

may remain clear for days and weeks, but on the other hand it may become dull within a short time, and this even without serious appearance of inflammation or of irritation. Such inconsiderable *halo-like opacities of the vitreous body* can almost without exception be ascribed to the presence of a foreign body; sometimes they still permit the dark or shining object to be seen through them. In some cases this opacity is found in the middle of the vitreous space, in others, after the body has settled down, in the region between the ocular equator and the ciliary body, on the lower wall. (Eduard von Jaeger, Berlin.) In some cases the foreign body remains seated near the entrance aperture, in others on the opposite wall; generally, however, it gets into the vitreous body after rebounding from the inner wall of the eye (Berlin). In one case observed in Vienna, a copper flake, retained in a suspended position, nearly in the centre of vitreous body, gradually approached the aperture by which it had penetrated, and towards which it seemed to be drawn by an opaque cord.

Redness, and especially *pain on palpation of one spot on the sclerotic*, may also point to the seat or at least the vicinity of a foreign body in the interior; to the latter even when no decided reaction has yet appeared (Von Graefe, "A. f. O.," IX. b. 80). Sometimes we find the *pupil dilated towards the direction* in which the object is lodged. Partial insensibility of the cornea should also be exam-

ined for; it may point to a division of ciliary nerves.

Prognosis.—On this part of the subject much has been already said in discussing the diagnosis. Since the publication of Eduard von Jaeger's treatise on the influence exercised by foreign bodies in the eye ("Oesterreichische Zeitschrift für Praktische Heilkünde," 1857), so many cases of foreign bodies lodged in the posterior part of the eyeball, with a relatively favorable termination, have been described, that one might be led to suppose that cases of this kind were on the average not dangerous, or at least relatively so. Even if we may assume, that foreign bodies, producing the same wound, and having the same character, are better borne in the posterior part of the eye, especially behind the ora serrata, than in or near the anterior segment of the uvea, the aspect of matters may still change materially by reason of the foreign body changing its location, or in consequence of dissolution of the incapsulating covering, and deleterious results may also occur in the other eye. As a matter of experience only very small bodies are permanently incapsulated, and *only exceptionally* such which, by reason of their size, weight, chemical character or jagged surface, do not offer favorable chances for the formation of a capsule.

Treatment.—Where neither the slight character of reactionary symptoms, nor the physical properties, speak for a favorable spontaneous termination,

and a corresponding expectant plan of treatment, we are limited to a choice between the operation of extraction, which, though it may not maintain the function, can still preserve the form of the eye, and enucleation. Where this last operation is not imperative, on account of imminent or rapidly spreading inflammation, it need not be proposed until several days have elapsed. If the injured person perceives that energetic and careful treatment does not suffice to relieve his pains, especially when he remarks that his still existing visual power is decreasing more and more, especially at the periphery, he will more readily conclude to make this great sacrifice. Where prodromata, or the first symptoms of a sympathetic inflammation of the other eye occur, these alone will suffice to bring the patient to terms.

Should, however, panophthalmitis be already established, the operation of enucleation cannot be considered free from danger, as in several cases thrombosis, with a fatal termination, has been observed, and if the iridocyclitis of the second eye has led to fusion between the iris or ciliary body and the capsule, the removal of the injured eye admits of a prospect of cessation of the sympathetic process only in exceptional cases. It has even been noticed that after enucleation the inflammation of the other eye, if virulent, has even been increased.

If the foreign body is situated not far behind

the lens, and not too distant from the pupillary region, the extraction of the lens may be undertaken, as has been already described in § 29. Should it be situated more peripherally, but still in front of, or at least not far behind the equator of the eyeball, we may hope to be able to extract it through the sclerotic. Von Graefe divided the sclerotic and choroid with a Beer's knife at a spot corresponding to the suspected seat of the foreign body, and with preference, a few millimetres in front of the equator, and parallel with it, to an extent of one-sixth to one-fifth of the corresponding circumference, in order to remove foreign bodies, reclinated lenses or parasites, from the vitreous. The places of puncture and counter-puncture are to be so chosen that neither of the two muscles, between which the incision is made, shall be totally divided.

This operation, after which Von Graefe secured even a partial restoration of vision, is applicable only "in recent cases, or in that stage where the beginning infiltration of the vitreous humor still admits of an ophthalmoscopic examination. In later stages, where the eyeball is filled with a connective tissue of new formation, such attempts at extraction are, of course, out of the question. Should an extraction fail, the patient is in as favorable a condition as before, because the acute suppurative choroiditis, which then develops, leads more rapidly to an atrophy of the eyeball, and the

expulsion of the foreign body, or else its inclosure in dense connective tissue, in consequence of which it is more easily borne. If sympathetic affection is threatening, enucleation is the only operation to be resorted to."

Another procedure, which is applicable for the purpose of extracting a foreign body, especially in such cases where the wound made by the foreign body itself may be used, has been practised by me with advantage, in a case of subretinal cysticercus in the equatorial region, situated inwards and below. After anæsthetizing the patient, and turning the eyeball upwards and outwards with a strong thread-loop, I first divided the mucous membrane and fibrous sheath, between the internal and inferior recti muscles, in the meridional direction from before backwards. The wound, about ten millimetres in length, being kept open by means of two fine hooks, and the blood sponged off, I placed a cataract-knife, with its back towards the eyeball, at a point from two to three millimetres distant from the corneal margin, and passed it through the globe towards a point five or six millimetres further backwards, on the same meridian. The hooklets were then employed to keep the wound of the eyeball open, and the cysticercus escaped without further assistance. In case of a foreign body, a curved pair of forceps might be used. An incision running in the meridional

direction is not apt to gape, nor to implicate the larger choroidal vessels.

A method for the removal of foreign bodies situated within the vitreous, if not attached to the walls, but which sacrifices the shape as well as the function of the eyeball, although it has not the revolting features of enucleation, has been proposed by Barton (Mackenzie, French edition, Paris, 1857). Barton passes a Beer's knife directly through the lens (as Wenzel did for cataract), to facilitate the escape of the lens, with which, at the same time, some of the vitreous, and occasionally the foreign body, escapes; if the latter does not happen, the corneal flap is to be removed with scissors and forceps, and then linseed poultices are to be applied over the closed lids. In all cases where a foreign body, such as a percussion cap, for instance, had penetrated, Barton found it a few days later in the conjunctival sac, or between the lids, or in the coagulum, closing the opening.¹

§ 31. *Foreign Bodies behind, or by the side of the Globe.*—In every case of injury of the lids or the conjunctiva, especially in cases of scalding, occurring as a result of explosions, we should bear in

¹ The above recalls a case in which I assisted my teacher, Dr. H. Knapp, in the (*in every particular*) successful extraction, through the sclerotic, by means of his "*foreign body hook*," of a gun-cap from the "centre of the vitreous chamber." ("Trans. Am. Ophthal. Soc.," 1873, p. 108.)—TRANS.

mind the possibility of a foreign body lying in the deeper parts of such a wound. The aperture of entrance may be very small, and for this reason, or on account of bloody effusion or inflammatory swelling, difficult of discovery. The following up of the channel of such a wound may become extremely difficult, because of the mobility of the conjunctiva over the subjacent tissues. In all these cases we should be the more guarded and careful, as the injured persons at times have no suspicion of a foreign body having struck the eye.

Other serious complications, as, for instance, cerebral concussion, may divert our attention; pain and hemorrhage about the eye frequently being only slight. It is certainly advisable, when clear statements or other points of evidence are not furnished, to carefully investigate the circumstances under which the injury took place. A thorough inspection of the instrument with which a wound has been made, may enable us to conclude with certainty that a foreign substance has entered or remains behind.

A very instructive case is noticed by Ed. Jaeger ("Cataracts and Cataract-Operations," p. 71). A fragment of a rocket-stick, about two inches long, entered the orbit of a lady present at an exhibition of fireworks, and penetrated deeply between the lower lid and the eyeball. The protrusion and immobility of the eyeball led the surgeon to palpate carefully, by which means he discovered the foreign body.

The introduction of the little finger, well oiled, into the conjunctival sac, advancing as far as possible into the cul-de-sac, between the lid and eyeball, serves as a means of diagnosis. Altered position of the eyeball, especially protrusion or impaired mobility (by the foreign body itself, or in consequence of hemorrhage, division of muscles, or inflammation), will direct suspicion to a foreign body. Symptoms of concussion, or wounds of the eyeball, do not exclude the possibility of a foreign body being deeply seated. Total loss of the power of vision may be caused by a wound of, or a foreign body in, the optic nerve; and also by its compression or by sudden stretching, the eyeball itself and the central nervous system remaining intact. These conditions usually lead to changes in the optic disk, which can be detected with the ophthalmoscope.

In older cases, it will depend on the changes established whether the presence of a foreign body can be determined or not. It may be necessary to make an opening in the cicatrix, or in some other practicable locality, in order to enable us to introduce a probe.

Prognosis.—An injury appertaining to this group can be viewed as a slight one only under specially favorable circumstances; as a rule it is grave and often associated with danger to life itself. There may be danger to life on account of the walls of the orbit, especially the upper one, being broken

through, or on account of the formation of an orbital abscess, which may extend to the brain. Large, ponderous, and jagged objects may remain for years without serious results, especially when tightly wedged in, while much smaller but movable ones not unfrequently lead to the formation of an abscess, which, provided an artificial opening of egress be not soon established, seriously endangers not only the eye, but also, especially when the abscess is near the roof of the orbit, life itself.

Limiting ourselves to a consideration of the foreign bodies remaining in the orbit, the first fact we have to notice is, that in a certain number of cases the wound of entrance closes, and the penetrating body remains for a period of *variable duration without causing any particular symptoms of irritation or of inflammation*. Closely allied is a second series of cases, where, after remaining months or years, without causing trouble during such period, inflammation and the formation of abscesses take place. In the majority of cases, however, an abscess is formed in the deeper parts before, or very shortly after, the external wound has healed. If the foreign body is not removed when the *abscess* is opened artificially or spontaneously, the ensuing relief is neither complete nor permanent, and the opening may reunite, or a fistula remain, which may, if the physician be called about this time, facilitate the discovery of the cause of the trouble.

For purposes of minute information, as to the cases belonging under this head, I consider it most expedient to refer the reader to the monograph of Zander and Geissler "On the Injuries of the Eye," Leipzig and Heidelberg, 1864, which also contains numerous records of pertinent cases. At the same time, I believe myself justified in refraining from any further remarks on the subject of treatment, supposing the reader to be familiar with topographical anatomy as well as general medicochirurgical principles.

CHAPTER III.

SCALDS AND BURNS.

§ 32. *General Remarks.*—Agents injuring the eye by virtue of their *high temperature* or their *chemical properties*, sometimes affect not only the cornea or the conjunctiva, or both, but frequently the skin of the lids also. An injury limited to the lids alone may also readily produce bad results as regards the function or the shape of the eye, and it will be expedient to premise by a few remarks on scalds and burns of the lids.

Injuries of this kind are caused by boiling hot fluids, water, tallow, or molten metals, lead, tin, iron at a red or white heat, burning segars, gunpowder, matches, and such like, while more or less deep cauterization is most frequently due to acids, such as nitric and sulphuric, or alkalies such as potash, lye, freshly slaked lime, mortar, et cetera, and occasionally to the introduction into the conjunctival sac of corrosive sublimate, red precipitate, cantharides, or tobacco powder.

The extent of a scald or a burn, unless it be at the same time very intense, is not of great import. Deep escharization may be of a very serious cha-

racter, even when of relatively slight surface extension, either by reason of the non-replacement of the destroyed portion, and extensive contraction of the cicatricial tissues, or because of the reaction consequent on the elimination of the dead tissue, by suppuration of the adjacent parts.

§ 33. Where the *scalding or burning of the lids* has not led to the formation of a dermal eschar, the *prognosis*, as far as the position and mobility of the lids are concerned, is, even when the injury is extensive, considered favorable. But should the eschar comprise the whole thickness of the skin, or extend down to the tarsus or even the tarso-orbital fascia and the periosteum of the orbital rim, even when of inconsiderable extent, we are not secure from serious results. Such results may be an *anomalous position of the cilia*, which may demand an operation, *malposition or closure of the puncta lachrymalia*, and if both lids are corroded at the inner or outer canthus, perhaps even *anchyloblepharon*. *Ectropium* should be apprehended where we find deep cauterization, destruction of the external commissure or the formation of a cicatricial cord, retracting towards the orbital rim, or a considerable loss of substance, for instance, half the skin between the orbital and palpebral margins, and, in case of an extensive implication of one lid, especially the upper, even *lagophthalmus* may be apprehended. In many

cases inflammation of the cornea, with more or less extensive suppuration, has been observed, while a lagophthalmus was in course of formation, and without previous direct injury to the cornea. Whether such a result can, under careful supervision, be in all cases prevented is a question which, for the present, we must leave undecided.

Treatment.—After accurate examination of the lids and the eyeball, and the removal of such foreign bodies or impurities as may be present, cold compresses are perhaps the best local application in the first period. Larger vesicles may be punctured, and flaps of tissue doomed to necrosis removed. Where the epidermis is wanting, or appears much macerated, the corresponding area is to be painted with a solution of lunar caustic, ten grains to the ounce, or it may be covered with a piece of linen soaked in ol. lini, or ceratum simplex, or with oiled wadding, over which we may perhaps place our cold compresses. Later, when the separation of the eschar has been effected, moist heat may be more agreeable and expedient. According to Mackenzie, *loc. cit.*, T. I., 155, *both* eyes should be kept closed under a charpie bandage, if possible, for several days, while the union by granulation is taking place, and the formation of an epidermic covering, from the margins inwards, be accelerated by touching the granulations with lunar caustic. Under certain circumstances this covering may be better produced by

the transplantation of epidermis according to Reverdin's method. Much better than the single bandage would it be to stitch both lids together at their free margins, and to leave the stitches until the epidermic covering of the wounded surfaces has formed. This method was first recommended by Debrou ("Gazette des Hôpitaux," 1860, N. 33), and afterwards by Graefe ("Arch. f. Ophth.," iii. a. iv. b., and x. b. 221).

Wherever keratitis ex lagophthalmo is threatened the cornea should at least be protected from the dust by a protective bandage, or by the wearing of curved protective spectacles, and besides kept clean by bathing with some bland decoction, such as decoctio althææ or malvæ. As to operative interference in case of ectropium, we should wait until the skin in the neighborhood has regained its normal appearance, or, at least, until the inflammatory swelling and reddening shall have totally disappeared.

§ 34. After *scalds of the eye*, we see on the cornea an opaque spot, desquamation of the epithelium, usually without a regular formation of vesicles, a semi-transparent pearly-gray or dense white opacity of the corneal substance (like boiled albumen), or the surface of the intensely opaque cornea yellow and corrugated. The signs of reaction soon appear, such as ciliary injection, redness, and swelling of the conjunctiva, pain, photophobia, and

lachrymation, and these symptoms vary even when the cornea alone is implicated. As a rule they are in proportion to the degree of the scald. Dryness of the opacified portion, diminished or entire loss of sensibility of the cornea or chemosis are to be regarded as ominous; febrile symptoms may be due to independent causes.

On the *conjunctiva*, if the scald be at all intense, we find a more or less extensive portion of the *conjunctiva bulbi* changed into a white, irregular or occasionally a somewhat depressed or prominent eschar, dotted with red on its margins, and provided the surrounding parts are not swollen, especially marked on that part nearest the cornea. The appearance of such portions, changed by thermal or chemical agents, is so characteristic, that having once been seen they will never afterwards be confounded with anything else, except, perhaps, with croupous or diphtheritic conjunctivitis. If the heated agent, for instance a red hot piece of iron, have charred the *conjunctiva bulbi*, and the eschar be already separated, the base of the wounded region may be formed by the denuded sclera; in which case it is surrounded by swollen *conjunctiva* studded with minute ecchymoses.

Provided the burn has not been caused by molten substances (such as lead, tin, wax, shellac, tar, and such like), over which the lids could close, the *palpebral conjunctiva*, frequently does not suffer

at all, or at most only on the free margins of the lids. Should this, however, have taken place, as when the molten or red-hot substance has passed between the lid and eye into the cul-de-sac of the conjunctiva, a more or less deep and broad symblepharon is to be expected. Occasionally we find portions or particles of the scalding object, which were accidentally driven in with it, deep down in the cul-de-sac or even still further back. Less dangerous is the contact with lighted segars, and the flying in of burning heads of matches, which usually touch the margin of the lids, or the conjunctiva bulbi near the inner canthus. The former generally leave behind ashes, which latter burn their way deeply into the caruncle or the palpebral margin, and cause the most excruciating pain. In case of the burning by gunpowder, it is not so much the burn itself, as the penetration of grains of powder or sand, perhaps also of metallic fragments or other substances, into the conjunctiva, cornea, or even deeper, thus stamping the injury as a very serious one, and changing the aspect of matters entirely.

§ 35. Of *substances acting chemically*, we mention in the first place freshly slaked lime, usually mixed with sand in the form of mortar, and sulphuric acid. The injuries caused by these are also most frequently brought up at criminal trials. The damaging influence of acids, almost without

exception, extends at the same time to the lids, while those of mortar are usually limited to the conjunctival sac and the cornea. Of the injuries to the lids we have previously spoken in § 33.

The *diagnosis* in an etiological respect, can almost without exception be made by the history of the case, except where chemically acting substances are introduced by malingerers. Where, however, corrosive substances have struck the eye with a certain degree of force, we should not neglect to examine for the results of a mechanical injury (sudden compression, or the entrance of one or more foreign bodies). The destructions caused to the cornea, to the conjunctiva and to the lids, by the chemical agent, can be easily recognized on the removal of the foreign substance. It is not essentially different from that produced by scalding. In the same manner, as in the case of scalds, we have to consider the extent, and the length of time during which the substance acted, as well as its degree of concentration; also the circumstance, whether it will be possible to remove all foreign impurities, such as sand and lime, as they occasionally stick to the superficial layers of the cornea.

§ 36. *Prognosis.*—*The consequences of a scald or burn* may not only be slight and transitory, but they may also be severe and irreparable.

a. Scalds and Burns of the Cornea.—Should nothing further take place during the first few days than a desquamation of the epithelium, and at most a hazy dulness of the cornea, we may expect a *restitutio ad integrum* of the cornea. The restoration of the epithelium proceeds from the margins towards the centre, and is accomplished at the longest, in from one to two weeks. Such, at least, I have found to be the case after the action of boiling hot fluids. If the cornea, as a whole, or in a large area, should be pearly gray, that is, opacified only to such a degree that the dark background is still visible through it, and perhaps even permitting the contours of the pupil to be recognized, and, at the same time, not devoid of sensibility, we may depend on the re-establishment of its transparency, unless suppurative destruction be apprehended from neighboring eschars, or be already in progress. Such portions as have the appearance of boiled albumen, and are dry and insensible, either become subject to a gradual retraction, or the dirty yellow and wrinkled patches suffer a gangrenous necrosis and elimination by suppuration, which process, of necessity, destroys the shape of the eye.

The cornea, as the scalding is not usually limited to it alone, may become agglutinated with an injured part of the opposing conjunctiva of one or both of the lids, and experience has

taught that it is next to impossible to avoid these sequelæ.

α. If a portion of the cornea and the adjacent parts of the conjunctiva be injured, and the latter tumefied, so that a part of this wounded surface overlaps the wounded cornea, fusion of the surfaces touching each other may take place, and thus the incentive be given for the gradual drawing together of a larger or smaller portion of the conjunctiva to produce a *pterygium*. Such a pterygium is not to be distinguished from the other form, found in persons of the working class, especially in masons, coachmen, farmers, etc., occurring after the thirtieth year without any specially assignable cause, except, perhaps, by the fact that it is not limited, as in the latter cases, to the inner or outer angles. It is further distinguished by the coexistence usually of a variable degree of symblepharon. It participates in all its troublesome symptoms, generally opposing, in a marked degree, the movements of the eyeball, but has this redeeming feature, that usually, after the reaction consequent on the injury, it remains stationary and does not advance over the cornea.

β. If the wounded part of the cornea touches a wounded part of an eyelid, usually the upper, and their continued contact cannot be prevented, adhesion takes place, producing a *corneal symblepharon*, a condition which is *incurable*, where the *adhering surfaces are extensive*, and even where only

about a third of the corneal area is concerned, and can hardly be operated upon without danger. Not unfrequently it is a *fait accompli*, when the patient presents himself. This state of things should not be confounded with that in which a pterygium-like membrane extends from the agglutinated lids and sclera to the cornea, for this permits of a much better prognosis.

b. On the *conjunctiva* the chief factors in the case are the size and extent of the charred area. Losses of substance of the conjunctiva itself (not only of its epithelium) are never replaced by reproduction, but by the contraction of the neighboring portions. By the contracting force of the cicatricial band the free margin of the lids may become rolled inwards, the mobility of the eyeball impaired, and the depth of the conjunctival sac considerably decreased. If a wounded surface of the eyeball extends so far towards the cul-de-sac, that it here touches a wounded surface of the lids, being in fact continuous with it, the agglutination of the injured surfaces progresses from the cul-de-sac, and a *scleral symblepharon* is produced, on the extent of which it will depend whether relief may be effected by an operation or not. If the cul-de-sac be implicated only to a slight extent, or not at all, so that no fusion takes place there, and we can pass a probe behind the symblepharon, the chief condition for a perma-

nent separation of the globe from the lid, is furnished.

A total symblepharon, or even one occupying only half of the palpebral conjunctiva, is to be considered incurable, as soon as it extends deeply ; and so also is a corneal symblepharon including a third of the corneal surface.

In most cases of symblepharon besides the visual disturbance and the impeded mobility of the eyeball, a more or less noticeable disfigurement of the face, with more or less lachrymation is found.

§ 37. *Treatment after Scalds and Burns of the Eye.*—At first we should carefully cleanse the eye with lukewarm water, and remove every particle of foreign substance sticking to the cornea or in the conjunctival sac. That bodies which continue their corroding action, such as lunar caustic, and caustic lime, should be removed as rapidly and completely as possible, by mechanical means, and not with water, which would intensify and spread their action over a larger area, needs scarcely to be mentioned. The removal of “cooled off” metallic fragments or flakes may occasionally necessitate the employment of some force, and consequently may cause mechanical injury. In a case of Ammon’s (his “*Zeitschrift*,” ii. p. 155), a drop of molten pitch adhering to the cornea was floated away by repeated instillations of lukewarm oil, and the external application of pieces of linen

saturated with it, after other mechanical manipulation had failed. The removal of mortar from the conjunctival sac usually gives great trouble.

We sometimes find collections of sand, or of lime, which lie deeply imbedded, and are difficult of discovery, even after careful eversion of the upper and lower lids. Their removal with a Daviell's scoop—so that no contusion or laceration be caused to the neighboring tissues—and their washing away by irrigation, are certainly less dangerous than the employment of a powerful water current, as by means of the latter water and foreign bodies might be forced deeper into the softened and loose subconjunctival tissue. Gosse-
lin recommends frequent instillations of a strong saccharine solution, to dissolve and remove particles of lime, especially when such adhere to the cornea. The saturated saccharine solution causes no new irritation. (Mackenzie, *loc. cit.*, i. 340.)

This is to be followed by strict *antiphlogistic* treatment. The patient should remain in bed, or at least in doors, in a darkened room, so as to avoid using the other eye until the dangers of a complication by iritis shall have passed. Solutions of sulphate of atropia should be instilled on account of threatening iritis. Ice-cold compresses relieve the pain and keep the reaction within bounds. Preparations of lead are to be avoided, and should at all events be kept out of the conjunctival sac. Leeching, perhaps phlebotomy, and drastic purges

may appear indicated as admissible and beneficial adjuvants. We should spare the usually considerably affected and excited patients the annoyance of counter-irritation, as its useful influence probably exists only in the imagination. Ointments of belladonna and opium will be best calculated to relieve the patient's insomnia and pain; still better is morphine, either externally or hypodermically.

For further treatment we must, as a rule, be guided by the *condition of the cornea*, according to the well-known principles laid down in suppurative keratitis, at the same time the favoring of the *elimination of eschars* should not be lost sight of. In place of cold we can use moist warm applications for ten or twenty minutes, at intervals of one or more hours. Thin linen compresses, soaked in chamomile infusion, form a very convenient means of applying moist heat.

One of our chief duties is the *prevention of the formation of adhesions between opposite wounded surfaces*. In the first few days, yes even hours, after the injury we may find that the folds of the swollen conjunctiva at the falx are extensively agglutinated by a tough plastic, at first hyaline, later opaque and firm exudation, furnished by the wounded surfaces, even where the latter have been deprived solely of their epithelium. This can be recognized in the cul-de-sac after eversion of both the lower and of the upper lid.

If powerful rotation of the eyeball to the opposite side does not suffice to prevent such bridge-like connections, a scoop or a button probe should be pushed forward in the underlying furrow, care being taken not to tear the softened conjunctiva. Occasionally, even large surfaces are not so firmly agglutinated, but that they may be separated by the scoop, or a spatula-like instrument of bone, tortoise-shell, or hard rubber, without danger of serious injury. (A very interesting case is related by E. Jaeger in his "Cataract and Cataract Operations," 1854, p. 64.) We should then consider whether the condition of the conjunctiva permits of the application to the bleeding surfaces of a five- or ten-grain solution of nitrate of silver, or whether use is to be made of the means now to be mentioned, by which a thin intervening layer is placed between the wounded surfaces, for the prevention of their reunion.

For the purpose of keeping apart larger opposing surfaces, deprived of their epithelium, various measures have been recommended. To these belong, first, those measures which have for their object the gaining of sufficient time to allow the wounded surfaces, by the contraction of surrounding parts, to become covered with epithelium, such as the continuous or oft-repeated drawing outwards of the lids, or even the temporary establishment of an ectropium. Where, however, the wounded surfaces pass into each other at the

cul-de-sac, these procedures are in vain, even if they were kept up with the greatest thoroughness, in spite of their inconvenience. Besides, it is altogether irrational to expose the conjunctiva to the atmosphere for any considerable period.

No less unfortunate and fruitless was the idea of keeping the wounded surfaces apart by the interposition of foreign objects. In order to carry out the notion, plates, or curved sheets of wax, lead, and enamel, the latter either flat or in the shape of artificial eyes, were proposed and used; independently of the fact that the inflammatory condition of the conjunctiva—not to mention an accompanying injury of the cornea—counterindicates the employment of anything that will still further irritate the membrane. The cicatrization takes place from the cul-de-sac (provided this be implicated) with such irresistible force, proceeding towards the palpebral free margin, that every mechanical resistance to it is out of the question. These measures have, however, been repeatedly recommended in all possible variations; although reliable instances of any good results are sought for in vain.

According to my experience, as long as no solid adhesion has been formed, repeated careful separation, and frequent drawing off of the lids, in combination with slight cauterization, or, where this is not admissible, the instillation of bland demul-

cent or oily fluids remains the best treatment. To this latter group belong fresh cream, or fresh soft butter, *crème céleste*, fresh oil of olives or of almonds, *mucilago semin. cydoniæ*. Glycerine, which would be very appropriate, in other respects, usually causes too severe smarting. How Wecker could come to condemn olive and almond oil, even when fresh, as appliances calculated to cause pain and irritation of the conjunctiva, I cannot understand. (*Traité des Mal. des Yeux*," Paris, 1867, t. i., 1860.) I have frequently used the *mucilago semin. cydoniæ*, chiefly because it adheres more readily to the moist laminae, and covers them equably. I intend hereafter to try the fresh linseed oil and simple syrup.

The results which have been achieved by the transplantation of epidermic islands, according to Reverdin, on various parts of the skin, admit of the hope that by the transplantation of thin layers of epidermis from the lips, in cases of threatened symblepharon when granulations are rapidly sprouting, we may be able to so far cover one of the wounded surfaces that a protection against a fusion is thereby afforded. Quite recently Prof. Otto Becker (*Wiener Med. Wochenschrift*," 1874, No. 46) has shown that in order to cover such wounded surfaces, the conjunctiva taken from a rabbit may be transplanted.

Concerning the operative interference in case of an already formed symblepharon, the same rule

holds good, which was announced previously with reference to ectropium, namely, that it should not be undertaken, before all traces of the inflammatory process have disappeared, and the cicatricial tissue be properly consolidated. Perhaps two or three months may elapse before this is ultimately accomplished.

CHAPTER IV.

AFFECTIONS OF THE EYE WHICH ARE CAUSED
ARTIFICIALLY OR ARE FEIGNED.

§ 38. IT may be to the interest of a person to provoke or maintain, artificially, an inflammation of the eye. ("Ophthalmia artificialis," after Mackenzie, Diseases of the Eye, Hewson, p. 588.) Some rub their lids with caustic, after previously extracting the lashes; others introduce various mechanically or chemically irritating substances into the conjunctival sac. Among the latter may be mentioned the bichloride and red oxide of mercury, sulphate of copper, caustic lime, unguent. cantharidis, snuff, tobacco-juice, ashes, and finally common salt.

The artificial inflammation of the margins of the lids might, when the person is kept under strict surveillance, be readily diagnosticated from spontaneous blepharitis ex-ulcerans, by the absence of the small funnel-shaped ulcers extending to deeper parts, and by the reproduction of the cilia. The inflammation could at most (provided an eschar produced by the caustic were still present) be confounded with diphtheritis, otherwise, only with an acute or chronic catarrhal conjunctivitis.

Diphtheritis could appear in the case of grown persons only by infection, or under particularly unfavorable external circumstances, and would be accompanied by febrile disturbance; at all events it would have run its course in from two to three weeks, while the artificially excited process would usually have to be kept up much longer, if its object is to be accomplished. If no cauterization can be proven, a careful examination of the conjunctival sac, *throughout its whole extent*, as well as of the secretions, may lead to the discovery of a foreign body. The limitation of the redness and swelling to a small area would also show that it is not a chronic catarrhal or blennorrhœal affection that we have to deal with; for in this case the conjunctiva is *equally* swollen, infiltrated, and reddened throughout its whole extent, perhaps somewhat more intensely on the upper lid, near the outer and inner ends of the convex borders of the cartilages. According to Mackenzie, soldiers suspected of artificial ophthalmia have been suddenly waked up at night, had their clothing completely changed, and then been transported to some other dwelling, all under constant surveillance, whereupon, on investigating the previous clothing and domicile, the "corpora delicti" were found.

According to Himly ("Krankheiten und Missbildungen" Berlin, 1843, II. B., p. 123), the frequent occurrence of *mydriasis* in those who were

subject to military duty, caused suspicion; they were received in the hospital and all their effects taken from them; notwithstanding this, the trouble continued until, all of a sudden, warm baths suddenly did away with it. The deceivers confessed having employed, on the advice of a veterinary surgeon, an extract of belladonna, concealing it beneath the nail of the great toe.

According to Zander and Geissler (*loc. cit.*, p. 531), it has happened that young men, in order to shirk military duty, have had a *cataract* produced by means of a fine needle, or a *corneal opacity*, through repeated touching of the cornea with lunar caustic. The latter might perhaps be differentiated from opacities due to other causes by a peculiar grayish black tinge of the conjunctiva. (Argyrosis.)

§ 39. When it is stated by any one that he is *short-* or *weak-sighted* in one or both eyes, he should be examined concerning the distance at which he can see objects of a definite size; and whether a recognition at a greater distance is possible when concave glasses of differing foci are employed. Should the latter turn out to be the case, short-sightedness is certainly present, and the focal distance of that concave lens, with which the vision was relatively the best, may be used to designate the degree of short-sightedness (myopia). For instance, should the eye in question distinctly per-

ceive objects at a distance with concave No. 11 or 12, but less distinctly with concave No. 14, we may conclude the myopia to be $\frac{1}{12}$. If, however, distant objects are recognized with a convex lens (the person examined need not know what kind of lens is held before him), such objects as an emmetropic eye recognizes at the same distance and in the same light without the aid of a glass, the supposed or affirmed myopia may turn out to be hypermetropia.

However, it is a fact that some, especially young, persons can, by practice, succeed in overcoming more or less powerful concave glasses by an exercised accommodation, and thus *simulate a high degree of myopia*. Paralyzing the accommodation by means of the repeated instillation of a solution of atropine, exposes this trick. At the same time we possess in the ophthalmoscope a more rapid and successful test. With it we can determine the refraction independently of any statements of the person examined, as every one familiar with this instrument knows.

The determination of the degree of visual acuteness is more difficult, where it is to the interest of the person examined to *feign a diminution* of it. The curvature and transparency of the cornea are to be examined by means of the reflected image, or by focal illumination, as also is the transparency of the other refractive media. Depreciation of vision through regular astigmatism, if not

of too low degree, can be detected by the ophthalmoscope, and so can any changes in the optic background (the optic disk, retina, or choroid) that could be the cause of amblyopia. The acuteness of vision, however, may be decidedly depreciated, notwithstanding the fact of our being unable to discover anything abnormal. Then, too, the deviation of one eye from the object which is fixed by the other, either constantly or only when very delicate objects are looked at, may speak for diminished acuteness of vision in the deflected eye, provided the reason of such deflection is not to be sought for in an abnormal or in a different refractive condition of the eyes. The eye excluded from binocular fixation on account of its diminished visual acuteness, usually deviates somewhat to the outside, frequently, however, in so slight a degree that the incorrect direction of the visual axis, as regards the object, can be recognized only on close observation. The non-active eye usually betrays its previous deviation by a motion from the incorrect position to a correct one, when a diaphragm is advanced between the active eye and the object fixed. Even the absence of this appearance will not justify an exclusion of the possibility of a diminished degree of visual acuteness, especially in recent cases.

Many amblyopic eyes, with negative appearances as regards the points just mentioned, see near objects better (always considering the degree

of refraction), when powerful *convex lenses* are held before them, because larger images are hereby formed on the retina. This will speak in favor of the person examined, and unfavorably, only in cases where repeated trials with different glasses do not elicit contradictory statements. The registration of the statements made on trials with *concave and convex glasses of various focal distances*, as a rule, is sufficient to expose all false statements. Believing that we are holding a convex or concave lens before his eye, while we have just chosen a plane glass, the simulator declares that he perceives objects less distinctly or enlarged, or diminished, etc.

§ 40. If *total blindness of one eye* be stated to exist, although its functional integrity has not suffered at all or is only interfered with in so far that it is excluded from binocular vision, the reaction of the iris will generally show whether we have to deal with an exaggeration or a simulation. The seeing eye is covered with charpie or cotton, in such a manner that we can be certain that no light can enter it. Then the eye to be examined is directed to the sky, and suddenly some opaque shade, for instance the hand, is placed before it without the eye being able (provided it were amaurotic) to notice this. Should the iris show a distinct tendency to contraction of the pupil, as soon as the shade is withdrawn, the eye not having

changed its position, at least quantitative perception of light is present; this can be judged to be the more perfect, the more rapid and extensive is the excursion of the iris. The absence of such excursive movement, however, does not justify us in deciding as to the loss of all qualitative or quantitative perception, for it may depend on an impairment of conduction in the ciliary nerves (iridoplegia). If the latter be the cause of the inertness and insensibility of the iris, it will be also manifest after liberation of the healthy eye, and varying of the illumination of the latter, by shading. Should total or partial loss of perception on the part of the retina of the examined eye be the cause of the slow, or even wanting, reaction of the iris, the latter will also be almost or altogether absent in the healthy eye, when the other one is alternately illuminated and shaded.

Graefe has given us an excellent means of detecting the simulation of unilateral amaurosis by the employment of prismatic glasses. ("A. f. O." II. a. 266.) If a prism, of an angle of refraction measuring 15–20 degrees, be placed before the healthy eye with its base directed upwards or downwards, while the person examined is requested to fix his eyes on a candle-flame held at a distance of several feet, and the latter states that he sees two flames, one above and one below, it is proof positive that he also sees the flame with the eye claimed to be amaurotic. If the in-

dividual in question be previously acquainted with this trick, he might state that he only saw a single image. He may still be caught. We now hold the prism with the refracting edge, horizontally, so that it alternately covers one half, or the whole pupil; should he deny seeing doubly at the times when half his pupil is covered by the prism, we need no longer doubt that he is an impostor.

Welz ("Klin. Monatsbl." 1867, p. 292) has shown us another use which can be made of prismatic glasses, in the exposure of the simulation of unilateral amblyopia or amaurosis, which it is true is only applicable where the presence of binocular vision is known, but which is also calculated to unmask the most skilful simulator. If we hold before one or the other eye a prism of 15 or 20 degrees, after binocular vision has been determined, with its base directed inwards or outwards, the diplopia momentarily caused, passes into simple vision after a few seconds, while an involuntary change in the position of the visual axis takes place by the eyeball turning around its vertical axis. Let us suppose, now, that the left eye is represented as amaurotic. The individual looks at an object lying within his visual range. If we now move a prism of, say 12 degrees, from below, before the right eye, in such a way that we can watch it sharply from above, and the patient states that he sees doubly, it is clear that he has also seen with the left eye. Should he assert that

he sees singly, we must watch the right eye at the instant when we take the prism away from below, while the individual is directed to look steadily at the object. If his right eye makes a movement inwards at the instant the prism is taken away, the person is then undoubtedly possessed of binocular vision.

By advancing the prism with its base directed towards the nose, the image of the object is diverted from the macula lutea towards the nasal side. The diplopia caused by this is involuntarily and irresistibly removed through the rotation of the macula lutea, towards the nasal side by the increased contraction of the external rectus muscle. With this the corneal centre is naturally moved to the temporal side. If now the prism is drawn away while the object is continually fixed, the same tendency to simple vision causes the increased tension of the external rectus to relax, and the eye to undergo a visible motion, until the picture of the object again falls on the macula lutea. We may then hold the prism before the eye represented as amaurotic. The movement of the eye immediately on the removal of the prism furnishes an incontestable proof that binocular vision took place while the object was fixed.

Kugel ("A. f. O." XVI., a. 343) recommends holding colored glasses before the eyes, for the recognition of simulated unilateral amblyopia or

amaurosis. "To discover this simulation, the dark colored yet transparent glass is placed before the eye represented as blind, the other glass of the same color but non-transparent, before the eye represented as seeing." This is done after having previously employed two differently colored transparent glasses.

I N D E X.

- A** BRASION of cornea, 100
 Abscess of cornea after concussion, 31
 caused by foreign body in the orbit, 162
 Amaurosis, after concussion of eyeball, 78
 simulated unilateral, *Graefe's* test for, 187
 Amblyopia, simulated unilateral, *Welz's* test for, 188
Ammon, molten pitch in the eye, case of, 174
 Anæsthesia, in removal of foreign bodies from anterior chamber, or iris, 142
 Anchyloblepharon after burns and scalds, 165
 Anterior capsule, irregular accumulations of pigment upon, following concussion or compression, 62
 chamber, hemorrhage into from concussion, 43
 Aphakia, after rupture of the globe from compression, 41
Arlt's monocular bandage, 108
 method of removing foreign bodies from vitreous, 158
 "Artificial ophthalmia," *Mackenzie*, 181
 Artificially caused, affections of the eye, 181
 Astigmatism, caused by luxation of lens, 66
 transitory irregular, after concussion of eyeball, 79
 Atresia of pupil after absorption of lens, 123
 Atropia, solution of, in simulated myopia, 184
 solution of, after burns or scalds, 175
Aub, case of rupture of the choroid from compression, 54
 case of stretching of the zonula of *Zinn*, following compression, 57
- B** ANDAGE, *Arlt's* monocular, 108
Barton's method, removal of foreign bodies from vitreous, 159
Becker, transplantation of conjunctiva for symblepharon, 179
 Belladonna ointment, after burns and scalds, 176
Berlin, case of gun-cap in lens, 144
 on retinal commotion, 77
 Blephorrhœa, dacryocistic, complicating contusions of cornea, 31
 Blepharitis marginalis, artificially produced, 181
 Burns of the eye, 164
 Brain symptoms, following concussion of globe, 77
- C** ALABAR bean, use of in luxation of lens into anterior chamber, 76

- Cataract following contusion of globe, 61
 following penetrating corneal wounds, 10
- Cerebral concussion, accompanying injuries of the eye, 160
- Changes in globe due to compression, 22
 in lens lying in anterior chamber, 72
 in luxated lens, 70
- Choroid, hemorrhagic extravasations following concussion, 51
 inflammation of, from foreign bodies, 152
 penetrating wounds of, with accompanying foreign bodies, 150
 ruptures of, from concussion or compression, 50
- Cicatrization after scalds and burns, special treatment of, 178
- Cilia, anomalous position of, after scalds or burns of lids, 165
- Ciliary body, injury of, 107
 muscle, paralysis of from compression or concussion, 83
- Closure of "puncta lachrymalia" after scalds and burns, 165
- Coloboma, traumatic of iris, 49
- Colored glass test for simulated unilateral amblyopia, 189
- Commotio retinæ, after compression or concussion, 76
- Complications of intra-ocular hemorrhage following compression or concussion, 46
- Compression of globe, 19
- Concussion of crystalline body, 57
 of globe, four cases of, 84
- Congenital ectopia of lens, 64
- Conjunctiva, foreign bodies in, 129
 scalds or burns of, 173
 wounds of, 94
- Contre-coup an alleged cause of choroidal rupture, 23
- Contusion of cornea, 31
- Cornea, abrasion of, 100
 changes in curvature after compression and concussion, 102
- Cornea, contusion of, 31
 deeply penetrating wounds of, 101
 fistula of, 110
 foreign body in, 131
 penetrating wounds of, 97
 rupture of by compression or concussion, 37
 suppuration of, 102
 scalds or burns of, 171
 wounds of, treatment of, 107
- Corneo-scleral margin, rupture at, from compression or concussion, 104
- Counter-irritants, after scalds and burns, 176
- Croupous conjunctivitis, scalds of conjunctiva similar to, 168
- Cyclitis, consecutive, following traumatic luxation of lens into anterior chamber, 87
- Cystic formation within the iris after penetrating wounds of the cornea, 105
- Cysticercus, removal of from vitreous, 158
- Cystoid cicatrization after penetrating wounds of the eye, 104
- Cysts, sub conjunctival, resulting from concussion or compression, 30
- D**ACRYOCYSTIC blennorrhœa, complicating contusions of cornea, 31
- Dark meniscus, as an ophthalmoscopic symptom of luxation of lens, 66
- Diagnosis of artificial conjunctivitis, 182
 of foreign body behind or near globe, 160
 of foreign bodies within the eye, 151
 of intra-ocular hemorrhage, 46
 of lens luxated into anterior chamber, 71
 of lens beneath the conjunctiva, 39

Diphtheritic conjunctivitis,
feigned, diagnosis of, 182
conjunctivitis, scalds of conjunctiva similar to, 168
Diplopia, monocular, after laceration of iris, 50
monocular, after lateral displacement of lens, 68
Direction of choroidal ruptures, 24
of lacerations of anterior zone of sclerotic, 25
laceration of uveal tunic due to compression, 25
Debrou, treatment of surfaces after scalds or burns, 167

ECTOPIA, congenital, of lens, 64
lentis (congenital?), case of, 87

Ectropium after scalds or burns, 165

Effects of sudden compression of eyeball, 21

Enucleation for foreign body in vitreous, 156

Episcleral injection, symptoms of after concussion, 79

Explanation of scleral ruptures caused by compression or concussion, 27

Expulsion of lens in rupture of sclera, 26

Extraction of foreign body from vitreous, 156

of luxated lens from anterior chamber, case of, 87

Extravasation of blood beneath conjunctiva, following compression or concussion, 29

FEIGNED amblyopia, 185
affections of the eye, 181
blindness, 186
mydriasis, 182,
myopia, 183
ophthalmia, 181

Feigned short sightedness, 183
unilateral amblyopia, 186
Kugel's test for, 189
Field of vision, limitation of, by hemorrhage and foreign bodies, 152
permanent defect of, 91
Focal illumination in diagnosis of foreign body in the vitreous, 153
Foreign body between lid and globe, 160
bodies behind the globe, 159
in anterior chamber, 136
in conjunctiva, 129
in cornea, 131
in globe, 124
in iris, 136
in lens, 142
in vitreous, 142
removal of, 140
treatment of, 136
prognosis of, 155
removal of (*Barton*), 159
treatment of, 149

GIESSLER, on concussion of the globe, 78

Glaucoma, lens in anterior chamber as a cause of, 73

Gosselin, saccharine solutions in scalds or burns, 175

Gun-cap in vitreous, case of, 159

Gunpowder, burns from, 169

HÆMOPHTHALMUS posterior, prognosis of, 47

Helmholtz, focal illumination, 98

Hemorrhage into anterior chamber, 43

into vitreous, following rupture of choroid and retina, case of, 91
into vitreous, 45

Hemorrhagic extravasations in the choroid, 51

Himly, artificial mydriasis, case of, 182

Hypopyon, following injury of lens, 119
following contusion of the cornea, 33

ICE compresses after scalds and burns, 175

Injuries of the cornea, treatment of, 34

Intra-ocular hemorrhage, 45
prognosis of, 47

Iridectomy after corneal fistula, 110

after removal of foreign body from lens, 142

for swollen lens, 122

Iridocyclitis, sympathetic, 156

Iridodialysis, after injuries, 48

Iridoplegia, following injury from a stone, 91

Iris, cysts of, after penetrating wounds, 105

foreign bodies in and behind, 136

laceration of, 48

paralysis of sphincter, 84

spastic contraction of, in compression and concussion, 80

treatment of cysts of, 106

of prolapse of, after injuries, 109

JAEGER, case of foreign body between lower lid and globe, 160

of gun-cap in anterior chamber, 137

Jacobs, case of fragment of stone in anterior chamber, 138

KERATITIS, after contusion of the cornea, 31

Knapp, case of rupture of choroid, 55

case of rupture of posterior lens capsule, 57

hook for removing foreign bodies from vitreous, 159

on concussion of the globe, 78

Knapp, theory of position of choroidal ruptures, 23

Kugel's test for simulated unilateral amblyopia, 189

LACERATION of anterior zone of sclerotic and uvea, due to compression, 25

of iris by compression or concussion, 48

prognosis and treatment of, 50

of tunica uvea, compression causing, 25

of the zonula, 62

Lateral displacement of the lens, 67

illumination to detect corneal opacities, 98

Lead, preparations of, in treating scalds and burns, 175

Leeches, after scalds and burns, 175

Lens, beneath the conjunctiva, after compression or concussion, 39

change in form and position of, after trauma, 89

changes in, after luxation into anterior chamber, 71

extraction of, from anterior chamber, 73

foreign bodies in the, 142

gun-cap within, case of, 144

hemorrhages near, 82

in vitreous, prognosis and treatment of, 72

lateral displacement of, prognosis and treatment, 67-69

luxated into anterior chamber, 71

luxation into anterior chamber, pre-existing (congenital?) ectopia of the same, etc., case of, 87

luxation of, into vitreous, case of, 71

metallic splinter in, case of, 145

opacity of, 112

prognosis of capsular wounds after injury, 118

- Lens, resorption of, after injury, 113
 shadow of, on retina, 75
 sub-luxation of, 64
 following injury, case of, 91
 producing myopia, 65
 swelling of, after injuries, 118
 traumatic sub-luxation of, into vitreous, case of, 84
 treatment of wounds of, 120
 wounds of, diagnosis and prognosis, 111, 113
 Lids, scalds and burns of, 165
 prognosis and treatment of, 166
 Lime, burns produced by, 169
 Luxation of lens, 69
 into anterior chamber, following compression or concussion, 71
 case of, 87

- M**ACKENZIE'S artificial ophthalmia, cure for, 181
 Macula lutea, changes in, after concussion of retina, 79
 Malposition of puncta lachrymalia, after scalds and burns, 165
Manz, theory of rupture of choroid and sclerotic, following compression, 26
 Match heads, burns from, 169
 Methods of preventing symblepharon, 177
 Monocular diplopia, after lacerations of the iris, 50
 in luxation of the lens, 68
 Mortar, burns produced by, 169
 Mydriasis, after luxation of lens, following compression or concussion, 70
 artificial, 182
 when lens is in vitreous, 75
 Myopia, caused by sub-luxation of lens, 65
 feigned, test for, 183
 following stretching of zonula, case of, 89

- O**BLIQUITY of crystalline lens, 66
 Opacity of anterior cortical substance, cause of, 60
 of lens, compression as a cause, 60
 "Ophthalmia artificialis," 181
 Ophthalmoscope in lateral displacement of lens, 67
 in simulated anomalies of refraction, 183
 Ophthalmoscopic, reflectory phenomena of lens in vitreous, 75
 Optic nerve, wounds of, 161
 foreign bodies in, 161
 Ora serrata, foreign bodies at or near, 155
 Orbital injuries and retinal commotion, 77

- P**AGENSTECHER, case of cili-um in anterior chamber, 137
 Palpation in diagnosis of foreign body, 154
 Palpebral conjunctiva, scalds of, 168
 Panophthalmitis, after foreign body penetrating into vitreous, 156
 after rupture of the globe, 42
 Paracentesis of anterior chamber for swollen lens, 121
 Penetrating wounds of conjunctiva and sclera, 95
 of cornea, causing iris cysts, 105
 of the eye, 94
 with foreign body remaining, 124
 Perforation of the cornea, 98
 Pigment on anterior lens capsule, following trauma, 62
 Prognosis of cataract after injury of lens, 113
 of foreign bodies in the cornea, 132
 in the orbit, 161
 in the vitreous, 155
 of intra-ocular hemorrhage, 47
 of lens luxated into anterior chamber, 72

- Prognosis of rupture of globe by
compression or concussion,
40
of scalds and burns, 170
- Progressive suppuration of cornea,
treatment of, 34
- Prolapse of the iris after pene-
trating wounds, 104
- Pterygium, caused by burns or
scalds, 172
- Pupil, dilatation of, towards
foreign body, 154
- Purkinje's* images, absence of, as
a test for lens in vitreous, 75
- Pus, accumulations of, in anterior
chamber after contusions of the
cornea, 33
- R**ECTI muscles, conjunctival
wounds accompanying in-
juries of the, 95
- Reflectory phenomena, from lens
in vitreous, 75
- Remarks upon foreign bodies
within the eye, 124
- Removal of foreign bodies from
anterior chamber, 140
of foreign body from vitreous,
Barton's me-
thod, 159
case of (*Knapp*),
159
- Rent in sclera, diagnosis of, 38
- Results of treatment of corneal
abscess, 37
- Retina, after contusion or concus-
sion of globe, 76
Berlin on commotion of, 77
detachment of, following
penetration of foreign
bodies, 152
inflammation of, following
penetration of foreign
bodies, 152
penetrating wounds of, 150
position of ruptures, following
compression or concussion,
23
- Retinal changes after compression
and concussion, 81
- Reverdin's* method of skin graft-
ing, 167
- Rothmund's* explanation of de-
velopment of iris cysts, 105
- Rupture of choroid, anterior or
posterior to equator, 55
following compression
and concussion, 50
diagnosis of, 51
treatment of, 56
and retina, case of, from
compression and con-
cussion, 91
of the anterior capsule after
compression, 57
of the cornea, 37
at corneo-scleral margin, 37
of globe, prognosis, 40
of inner tunics of globe, 43
of posterior area of sclerotic,
38
of sclera, caused by compres-
sion and concussion, 26
of the sclerotic, predisposing
conditions of, 29
of zonula, after compression
and concussion, 65
- Rydel*, partial opacities of lens,
following injuries, 113
- S**AEMISCH, operation for cor-
neal abscess, 34
- Scalds of the conjunctiva, symp-
toms of, 168
of the cornea, symptoms of,
167
of the globe, 164
- Schröter*, case of rupture of the
sclerotic, 38
- Scleral symblepharon, after scalds
and burns, 173
treatment of,
173
- Sclerotic, case of rupture of, 27
lacerations of anterior zone of,
by blunt force, 25
rupture of, 37
in compression, 26
wounds of, with complicating
injuries, 95

- Sclerotic wounds, symptoms and prognosis of, 96
 Segar burns of eye, 169
 Shadow of lens on retina, 75
 Simulation of myopia, 183
 Sphincter pupillæ muscle, paralysis of, 83
Stellwag, case of rupture of choroid, 54
 Stretching of the zonula by concussion and compression, 62
 Sub-conjunctival hemorrhage, following concussion and compression, 29
 Sub-luxation of lens, 64
 prognosis and treatment, 69
 following injury, case of, 91
 Substances acting chemically to burn or scald, 179
 used to produce artificial ophthalmia, 181
 Successful removal of foreign body from vitreous, 159
 Sudden compression, effects of, 21
 Sulphuric acid, burns produced by, 169
 Suppuration of cornea, after contusion, 31
 after penetrating wounds, 102
 Suspension of accommodation, cause of, 65
 Suspensory ligament of lens, stretching of, 57
 Swollen lens, 119
 Symblepharon, corneal, after scalds or burns, 172
 methods to prevent formation of, 177
 when to operate, 180
 Sympathetic disease, after rupture of globe, 41
 irido cyclitis, after rupture of globe, 43
 Symptoms of corneal perforation, 98
 of foreign body within the eye, 152
 of intra ocular hemorrhage, 46
 Symptoms of lens in the vitreous, 71
 of sub-luxation of lens, 65
 of obliquity of lens, 66
 Synchysis of vitreous humor, after rupture of choroid, 61
 Synechia, after absorption of lens, 122
- TENSION** as a cause of choroidal rupture, 24
 of globe, after injury of lens, 112
 after commotion of retina from concussion, 80
 Tests for feigned amblyopia, 185
 myopia, 183
 Thrombosis, following enucleation for foreign body, 156
 Total symblepharon, after burns or scalds, 174
 Transmission of force applied to globe, 23
 Transplantation of epidermis, after burns and scalds, 167
 Treatment of adhesions after scalds and burns, 179
 of scalds and burns, 174
 of choroidal rupture, 56
 of contusion of cornea, 34
 of foreign bodies in anterior chamber, 139
 in cornea, 132
 in lens, 144
 in vitreous, 155
 of lens in anterior chamber, 73
 of obliquely penetrating foreign bodies, 135
 of rupture of the globe, 42
 of scalds and burns of the lids, 166
 of vertically impacted foreign bodies, 135
 Tremulous iris, in myopia, 65
 the symptom of, 65
 Tunica-nvea, laceration of in compression or concussion, 25
 Turnbull, Chas. S., foreign body in vitreous, case of, 150

ULCUS corneæ serpens, after
contusion of cornea, 34
Unilateral amaurosis, simulated,
187
cataract, following contusion,
60
Uveal ruptures, cause of, *Arlt* on
the, 83
tunics, rupture of, 43

VITREOUS, removal of foreign
bodies from,
Arlt's method,
158
Barton's me-
thod, 159
foreign body in, case of, 150
prognosis of, 155
halo-like opacities of, symp-
tom of, 154
hemorrhages into, from com-
pression or concussion,
45
synchysis after, 61
treatment of prolapse of, 109
wounds of, 150
Von Graefe, case of metallic splin-
ter in lens, 145

Von Graefe, functional test for light
perception in intra-ocular
hemorrhage, 45
method of detecting simulated
blindness, 187
of removing foreign
bodies from vitreous,
157

WEAK-sightedness, feigned, 183
Weber, lachrymal knife to
reopen corneal abscess, 36
Wecker, treatment of adhesions
after scalds or burns, 179
Wernke's method of making para-
centesis of anterior chamber for
swollen lens, 121
Welz, prismatic test for unilateral
amaurosis, amblyopia, 188
Wounds of conjunctiva, 94
of cornea, 97
of lens, 111
in posterior portion of globe,
150

ZONULA, laceration of, 62
limit of extension of, 63
of *Zinn*, case of stretching, 57



